An evaluation of arrival metaphylaxis with enrofloxacin compared to tulathromycin in feedlot cattle at high risk of developing bovine respiratory disease in Mexico

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Abstract

In this large-pen commercial field trial, mixed beef-breed bulls and heifers were randomly allocated at feedlot arrival to 1 of 2 experimental groups: ENRO or TULA. Animals in the ENRO group (10 multi-pen lots; 2037 animals) received a subcutaneous injection of enrofloxacin at a dosage of 3.4 mg/lb (7.5 mg/kg) body weight once at allocation. Animals in the TULA group (10 multi-pen lots; 2036 animals) received a subcutaneous injection of tulathromycin at a dosage of 1.1 mg/lb (2.5 mg/kg) body weight once at allocation. Study animals were housed by experimental group in commercial feedlot pens and followed from allocation until slaughter. There were no statistical differences detected in any of the animal health or feedlot performance outcome variables between the experimental groups at the $P < 0.050$ level. Given the lack of detectable statistical differences in animal health and feedlot performance outcome variables in the current study, the relative cost effectiveness of metaphylaxis programs utilizing enrofloxacin or tulathromycin in mixed beef-breed bulls and heifers at high risk of developing bovine respiratory disease should be dependent on the relative cost of each program, as well as any intangible attributes such as syringability, storage requirements, potential for antimicrobial resistance, etc.

Key words: Baytril Max formula L.A., Draxxin, shipping fever, fluoroquinolone, beef

Introduction

Bovine respiratory disease (BRD), also commonly referred to as undifferentiated fever and historically known as "shipping fever", continues to be one of the most common animal health concerns in commercial feedlot production.[1,2,3] Although feedlot operations have become more sophisticated in managing health problems, significant economic losses from BRD and histophilosis continue to be related to increased morbidity and mortality rates, reduced feedlot performance, and metaphylactic and therapeutic regimen costs.[2,4] The economic losses attributable to BRD are estimated to cost the North American cattle industry greater than $500 million USD annually.[5] A more recent retrospective study involving 73,067,534 cattle showed an increasing trend in overall mortality in lots that closed from January 2005 to September 2014, with BRD mortality comprising 47% of total mortality.[6] Therefore, it is important to continually seek the most efficacious, practical, and cost-effective BRD prevention and treatment strategies based on high-quality field trial data.

Enrofloxacin[a] is a commercially available fluoroquinolone antimicrobial licensed in Mexico for the treatment of BRD in beef cattle. Enrofloxacin and other fluoroquinolone antimicrobial formulations have been shown to be of similar efficacy for treatment of BRD as tulathromycin.[b,7,8] However, there are few studies reported in the literature comparing the relative effects of using enrofloxacin versus tulathromycin for arrival metaphylaxis in Mexican feedlot cattle. Therefore, the objective of this study was to determine the relative effects of using enrofloxacin compared to tulathromycin for arrival metaphylaxis on animal health and feedlot performance outcomes in mixed beef-breed bulls and heifers at high risk (HR) of developing BRD under large-pen commercial production conditions in Mexico.

Materials and methods

General overview

In this large-pen commercial field trial, mixed beef-breed bulls and heifers were randomly allocated at feedlot arrival to 1 of 2 experimental groups: ENRO or TULA. Study animals were housed by experimental group and sex in commercial feedlot pens and were followed from allocation until slaughter. There were 10 replicates allocated to the study, with each replicate comprised of 1 multi-pen lot (experimental unit) from each experimental group (all pens within a replicate contained either bulls or heifers, but not both). Outcome variables were measured from allocation to slaughter to evaluate the relative effects of each metaphylaxis program on animal health and feedlot performance outcomes. Statistical analyses were used to determine the probability of whether differences in outcome variables between the experimental groups were due to differences in the experimental protocol or random chance.

All procedures involving live animals were approved by the Feedlot Health Management Services, A Division of TELUS Agriculture Solutions Inc. (Feedlot Health) Animal Care Committee (a holder of a Certificate of Good Animal Practice) and in accordance with guidelines put forth by the Canadian Council on Animal Care (2009), with informed consent from the animal owners.

Study facilities

The study was conducted at a commercial feedlot in Durango, Mexico. The basic design of the feedlot is representative of standard designs used in Mexico. Animals were housed in open-air, dirt-floor pens that are arranged side by side with central feed alleys and approximately 30% shade coverage over the pens. Each handling facility is equipped with an individual animal scale and a chute-side computer with individual animal data collection and management software.[c,d]

Study animals

Candidate animals for the study were mixed beef-breed bulls and heifers that arrived between 09-May-2019 and 18-February-2020, inclusive. At the time of study allocation, each animal received health and production products as per standard commercial feedlot practices. In brief, all animals received an experimental group-specific metaphylactic antimicrobial, an intramuscular (IM) modified live virus vaccine[e] at a dose of 2 mL/animal, a subcutaneous (SC) *Mannheimia haemolytica* bacterin-toxoid[f] at a dose of 2 mL/animal, an intranasal modified live virus vaccine[g] at a dose of 2 mL/animal, an IM anthrax spore vaccine[h] at a dose of 2 mL/animal, a pour-on flumethrin[i] at a dosage of 0.45 mg/lb (1 mg/kg) body weight (BW), and an estradiol/trenbolone acetate combination growth implant[j] in the middle one-third of the ear at a dose of 100 mg of trenbolone acetate and 14 mg of estradiol benzoate per animal (all products given once at the time of allocation). Heifers received an IM abortifacient[k] for pregnancy termination at a dose of 5 mL/animal once at the time of allocation. Weight was recorded for each animal. With the exception of the experimental group-specific metaphylactic antimicrobial, all health and production products received throughout the study were standardized across experimental groups within a replicate.

Experimental design

An a priori sample size was calculated based on the expected differences between the experimental groups using variance estimates for overall mortality and initial BRD treatment rate from previous studies conducted by the investigators in the intended study population. Based on the historical variance estimate for overall mortality, a baseline overall mortality of 1.94%, an expected overall mortality difference between the experimental groups of 1.5%, an alpha level of 0.05, a power of 90%, and a 2-sided test, it was calculated that 10 replicates were required. Including 10 replicates was calculated to be sufficient to detect a 3.0% difference in initial BRD treatment rate (baseline initial BRD treatment rate of 4.39%, an alpha level of 0.05, a power of 90%, and a 2-sided test).

In this large-pen commercial field trial, animals were randomly allocated at arrival processing to 1 of 2 experimental groups using a proprietary computer-generated allocation table: ENRO or TULA. Animals in the ENRO group (10 multi-pen lots; 2037 animals) received a SC injection of enrofloxacin at a dosage of 3.4 mg/lb (7.5 mg/kg) BW once at allocation. Animals in the TULA group (10 multi-pen lots; 2036 animals) received a SC injection of tulathromycin at a dosage of 1.1 mg/lb (2.5 mg/kg) BW once at allocation.

Study animals were housed by experimental group and sex in commercial feedlot pens. The experimental unit was the multi-pen lot, a production unit commonly used by large-scale commercial cattle feeding operations throughout the industry. Each multi-pen lot was comprised of multiple commercial feedlot pens from the same experimental group and contained only study animals of the same sex, with 10 multi-pen lots allocated to each experimental group (average 200 animals/multi-pen lot; range 112 to 250 animals/multi-pen lot). The average initial individual animal weight of multi-pen lots allocated to the study was approximately 489 lb with a range of 465 to 507 lb (average 222 kg; range 211 to 230 kg).

Feeding program

Water and standard mixed complete feedlot diets, formulated to meet or exceed the nutritional requirements for beef cattle,[9] were offered ad libitum throughout the feeding period. Feedlot diets were blended in truck-mounted mixer boxes equipped with electronic load cells. Diets were delivered to pens twice daily. Study animals were conditioned to a high-concentrate diet utilizing multiple transition diets. Diet formulations and diet changes were based on commercial feedlot protocols.

Animal health

Experienced animal health personnel, blinded to the experimental status of each pen, observed the study animals once daily for evidence of disease. Animals deemed to be "sick" by animal health personnel (based on subjective criteria such as general appearance, attitude, gauntness, reluctance to move, etc.) were individually sorted from pen mates, diagnosed, and treated as per the standard feedlot protocols provided by the consulting veterinarian(s). Subsequent to treatment and depending on the disease diagnosis and severity, study animals were either sent to a hospital pen for further treatment or returned to the commercial feedlot pen of origin. The treatment events, including the treatment date, the presumptive diagnosis, drug(s) administered, and dose(s) used, were recorded using a commercially available software program.[d]

The case definition for BRD was a lack of abnormal clinical signs referable to body systems other than the respiratory system and no previous treatment history for BRD. These clinical signs may have included, but were not limited to, nasal discharge, coughing, and increased respiratory rate. If an animal came through the chute presenting symptoms referable to systems other than the respiratory system, the animal was not eligible for BRD treatment.

All animals identified as "sick" by animal health personnel subsequent to initial therapy with clinical signs attributable to the same disease process were defined as relapses (i.e., cases that relapsed were defined as first, second, or third relapses as appropriate). Animals were deemed to be "chronics" if they spent longer than 14 consecutive days in a hospital pen, underwent 3 or more treatment regimens for lameness, or underwent 4 or more treatment regimens for the same disease/condition other than lameness. Chronics that did not die during the study were defined as wastage. All diseases were treated as per standard feedlot protocols developed by the consulting veterinarian(s) using a hierarchical evidence-based approach and economic modeling to determine the most cost-effective treatment protocol for each disease. Treatment protocols for all diseases (initial treatment and relapse therapy) were standardized across experimental groups within a replicate. The treatment protocol for initial BRD treatment was an SC injection of florfenicol and flunixin meglumine[l] at a dosage of 18.1 mg/lb (40.0 mg/kg) BW once. The treatment protocol for first BRD relapse treatment was a SC injection of

enrofloxacin at a dosage of 3.4 mg/lb (7.5 mg/kg) BW once. The treatment protocol for second BRD relapse treatment was a SC injection of ceftiofur crystalline free acid sterile injectable suspension[m] at the base of the ear at a dosage of 3.0 mg/lb (6.6 mg/kg) BW once. Individual animal dose was determined based on the BW at the time of each BRD diagnosis.

A gross post-mortem examination was performed on each animal that died when appropriate based on carcass condition (e.g., not autolyzed). In some instances, a Feedlot Health veterinarian conducted the post-mortem examination on site and determined the cause of death based on the findings of the clinical history and gross post-mortem examination. In other instances, trained personnel prosected the dead animals using a standardized method to capture appropriate digital images as outlined in the written necropsy protocol provided by Feedlot Health.[10] Subsequently, all digital images were electronically transferred to Feedlot Health and the cause of death for each dead animal was determined based on the clinical history and findings of the gross post-mortem examination by a Feedlot Health veterinarian. The individual weights of all animals that died were collected by feedlot personnel.

Marketing

The feedlot used standardized procedures to sort animals into production/marketing cohorts for optimization of production, marketing, and pen utilization. Within each production/marketing cohort and replicate, an equal number of animals from each experimental group were shipped and slaughtered within 1 to 4 days of each other at the same packing plant between 17-Dec-2019 and 13-Oct-2020, inclusive.

Data collection and management

Over the course of the trial, all individual animal feedlot data were collected using commercially available software programs.[c,d] At enrollment, initial weight was measured for each animal to assess the homogeneity of the animals in each experimental group. Daily feed data were captured electronically using the data collection systems in each feed truck and these data were electronically uploaded and stored in the feedlot's administrative software system. At slaughter, the weight of each carcass was collected using the data capture system in place at the packing plant. All study data were entered or electronically imported into a spreadsheet program,[n] collated, and verified.

Ancillary production variables were calculated for each multi-pen lot to describe the feedlot production system. Outcome variables describing animal health and feedlot performance (on both a live weight basis and carcass weight basis) outcomes were calculated for each multi-pen lot. Definitions and formulae used to calculate ancillary production, animal health, and feedlot performance lot-level outcome variables are summarized in Table 1.

Statistical analysis

Data were analyzed using a commercially available analytical software program[o] (SAS) to compare the ENRO and TULA groups. Animal health data were analyzed using the GENMOD procedure in SAS with Poisson regression in a log-linear model for experimental group effects and adjusted for clustering of observations (lot nested within replicate) with generalized estimating equations.[11] The baseline, ancillary production, and feedlot performance data were analyzed using the GLIMMIX procedure in SAS with the fixed effect of experimental group and the random effect of replicate nested within sex.[12] Baseline variables were tested as covariates of the feedlot performance variables and included in those final models if statistically significant ($P < 0.050$).

Results

The baseline and ancillary production data summary is presented in Table 2. The experimental groups were considered homogenous ($P \geq 0.050$) with respect to the baseline variable average initial weight. There were no differences detected for any ancillary production variables between the experimental groups at the $P < 0.050$ level. In addition, there were no interactions between experimental group and site or sex detected at the $P < 0.050$ level for any of the outcome variables.

The animal health data summary is presented in Table 3. There were no differences detected in any of the morbidity or mortality outcomes between the experimental groups at the $P < 0.050$ level.

The feedlot performance data summary is presented in Table 4. With respect to feedlot performance on both a live weight basis and a carcass weight basis, there were no differences detected in average daily gain or feed conversion between the experimental groups at the $P < 0.050$ level.

Discussion

The objective of this study was to determine the relative effects of using enrofloxacin compared to tulathromycin for arrival metaphylaxis on animal health and feedlot performance outcomes in mixed beef-breed feedlot bulls and heifers at HR of developing BRD under large-pen commercial production conditions in Mexico. No differences were detected between enrofloxacin and tulathromycin in any of the animal health or feedlot performance outcomes evaluated in this study.

A small-scale study conducted by Crosby et al. at a stocker operation in Georgia, USA, in auction-derived beef-breed bull and steer calves compared the use of an American-licensed enrofloxacin[p] (licensed for both the treatment and control of BRD associated with *M. haemolytica*, *Pasteurella multocida*, *Histophilus somni*, and *Mycoplasma bovis* in beef cattle) and tulathromycin[q] for arrival metaphylaxis.[13] With respect to morbidity rates, the results of the present study differ from the observations of Crosby et al., which reported increased morbidity rates attributed to BRD in the enrofloxacin group during the 45-day study period.[13] With respect to mortality rates, no differences were observed between the 2 groups in either study. It is important to note that the morbidity (33.7% and 18.3% in the enrofloxacin and tulathromycin groups, respectively) and mortality (12.2% and 10.1% in the enrofloxacin and tulathromycin groups, respectively) rates in Crosby et al. were much higher than those observed in the present study.[13] These differences suggest that the risk of developing BRD in the study by Crosby et al. was much higher than the present study, which used cattle in Mexico at high risk of developing BRD.[13] To differentiate these apparent differences in risk, the present authors suggest that characterizing these study populations based on the respective morbidity and mortality rates observed may help readers determine the external validity of each study for use in populations of animals with which they work.

Table 1: Definitions and calculations for lot-level variables from a study evaluating enrofloxacin compared to tulathromycin for arrival metaphylaxis in feedlot cattle at high risk of developing bovine respiratory disease in Mexico.

Ancillary production variable		
Slaughter weight	=	the total net live weight prior to slaughter divided by the # of animals sold and represents the average net live weight of animals sold for slaughter
Weight gain	=	average slaughter weight minus the average allocation weight and represents the average weight gain of animals sold for slaughter
Carcass weight	=	total carcass weight at slaughter divided by the # of animals sold and represents the average carcass weight of animals sold for slaughter
Dressing percentage	=	total carcass weight at slaughter divided by the total weight at slaughter expressed as a percentage
DOF	=	average slaughter date minus the average arrival date and represents the average # of days on feed of animals sold for slaughter
DOF Initial BRD treatment	=	average initially BRD treatment date minus the average arrival date and represents the average # of days on feed of animals initially treated for BRD
DDMI	=	total quantity of feed consumed (100% dry matter basis) divided by the # of animal days and represents the pounds of feed consumed per animal per day
Animal health variable		
Initial BRD treatment	=	# of animals initially treated for BRD divided by the # of animals allocated
First BRD relapse	=	# of animals treated for first BRD relapse divided by the # of animals initially treated for BRD
Chronicity	=	# of animals with chronic disease (all causes) divided by the # of animals allocated
Wastage	=	# of animals with chronic disease (all causes) that did not die divided by the # of animals allocated
Overall mortality	=	# of mortalities (all causes) divided by the # of animals allocated
BRD mortality	=	# of mortalities due to BRD divided by the # of animals allocated
Histophilosis mortality	=	# of mortalities due to histophilosis divided by the # of animals allocated
Lame mortality	=	# of mortalities due to lameness divided by the # of animals allocated
Metabolic mortality	=	# of mortalities due to metabolic disease divided by the # of animals allocated
Other mortality	=	# of mortalities (causes other than those previously listed) divided by the # of animals allocated
Feedlot performance variable		
ADG – LWB	=	(total net live weight prior to slaughter plus total weight of animals shipped for salvage slaughter plus total weight of animals that died minus total allocation weight) divided by the # of animal days
ADG – CWB	=	(total carcass weight divided by a fixed dressing percentage (63.5%) plus total weight of animals shipped for salvage slaughter plus total weight of animals that died minus total allocation weight) divided by the # of animal days
DM:G – LWB	=	DDMI divided by ADG – LWB
DM:G – CWB	=	DDMI divided by ADG – CWB

= number, ADG = average daily gain, BRD = bovine respiratory disease, CWB = carcass weight basis, DDMI = daily dry matter intake, DM:G = dry matter intake to gain ratio, DOF = days on feed, LWB = live weight basis.

All animals were allocated at feedlot arrival.

Table 2: Baseline and ancillary production data summary from a study evaluating enrofloxacin compared to tulathromycin for arrival metaphylaxis in feedlot cattle at high risk of developing bovine respiratory disease in Mexico.

	Experimental group			
Production variable	**ENRO**	**TULA**	**SEM**	***P* - value**
Allocation weight (lb)	488.8	489.6	± 3.3	0.593
Slaughter weight (lb)	1134.1	1134.7	± 13.2	0.886
Weight gain (lb)	645.3	645.1	± 15.0	0.982
Carcass weight (lb)	718.3	718.7	± 7.3	0.893
Dressing percentage (%)	63.35	63.34	± 0.23	0.933
Days on feed (day)	270.4	270.9	± 6.0	0.502
Days on feed at initial BRD treatment (day)	57.8	51.8	± 8.1	0.614
Daily dry matter intake (lb/animal/day)	16.80	16.45	± 0.37	0.279

All animals were allocated at feedlot arrival. Animals in the ENRO group (10 multi-pen lots; 2037 animals) received a subcutaneous (SC) injection of enrofloxacin (Baytril Max™ formula L.A., Bayer de Mexico, S.A. de C.V., Ciudad de Mexico) at a dosage of 3.4 mg/lb (7.5 mg/kg) body weight (BW) once at allocation. Animals in the TULA group (10 multi-pen lots; 2036 animals) received a SC injection of tulathromycin (Draxxin®, Zoetis Mexico, S. De R.L. De C.V., Ciudad de Mexico) at a dosage of 1.1 mg/lb (2.5 mg/kg) BW once at allocation.

Data were analyzed using the GLIMMIX procedure of SAS® (Version 9.4, SAS Institute Inc, Cary, North Carolina) with the model containing the fixed effect of experimental group and the random effect of replicate nested within sex.

One replicate was excluded from the model for Days on Feed at Initial BRD treatment because there were no initial BRD treatments in 1 of the experimental groups (affecting model stability).

BRD = bovine respiratory disease, SEM = standard error of the mean.

Table 3: Animal health data summary from a study evaluating enrofloxacin compared to tulathromycin for arrival metaphylaxis in feedlot cattle at high risk of developing bovine respiratory disease in Mexico.

	Experimental group		
Animal health variable	**ENRO**	**TULA**	***P* - value**
Morbidity			
Initial BRD treatment (%)	4.10	4.39	0.822
First BRD relapse (%)	43.43	47.26	0.489
Chronicity (%)	0.82	0.77	0.805
Wastage (%)	0.64	0.62	0.867
Mortality			
Overall mortality (%)	1.63	1.94	0.523
BRD mortality (%)	0.55	0.39	0.620
Histophilosis mortality (%)	0.00	0.14	NA
Lame mortality (%)	0.00	0.05	NA
Metabolic mortality (%)	0.28	0.34	0.751
Other mortality (%)	0.80	1.02	0.528

All animals were allocated at feedlot arrival. Animals in the ENRO group (10 multi-pen lots; 2037 animals) received a subcutaneous (SC) injection of enrofloxacin (Baytril Max™ formula L.A., Bayer de Mexico, S.A. de C.V., Ciudad de Mexico) at a dosage of 3.4 mg/lb (7.5 mg/kg) body weight (BW) once at allocation. Animals in the TULA group (10 multi-pen lots; 2036 animals) received a SC injection of tulathromycin (Draxxin®, Zoetis Mexico, S. De R.L. De C.V., Ciudad de Mexico) at a dosage of 1.1 mg/lb (2.5 mg/kg) BW once at allocation.

Data were analyzed using the GENMOD procedure of SAS® (Version 9.4, SAS Institute Inc, Cary, North Carolina) using Poisson regression in a log linear model for experimental group effects and adjusting for clustering of observations (lot nested within replicate) with generalized estimating equations.

One replicate was excluded from the model for First BRD Relapse because there were no initial BRD treatments (and no risk of First BRD Relapse) in 1 of the experimental groups (affecting model stability).

BRD = bovine respiratory disease.

NA = not applicable; model would not converge due to the small number of events.

Table 4: Feedlot performance data summary from a study evaluating enrofloxacin compared to tulathromycin for arrival metaphylaxis in feedlot cattle at high risk of developing bovine respiratory disease in Mexico.

	Experimental group			
Feedlot performance variable	**ENRO**	**TULA**	**SEM**	***P* - value**
Average daily gain (lb/day)				
Live weight basis	2.40	2.40	± 0.11	0.984
Carcass weight basis	2.38	2.38	± 0.09	0.974
Dry matter intake to gain ratio				
Live weight basis	7.09	6.94	± 0.19	0.173
Carcass weight basis	7.11	6.96	± 0.18	0.168

All animals were allocated at feedlot arrival. Animals in the ENRO group (10 multi-pen lots; 2037 animals) received a subcutaneous (SC) injection of enrofloxacin (Baytril Max™ formula L.A., Bayer de Mexico, S.A. de C.V., Ciudad de Mexico) at a dosage of 3.4 mg/lb (7.5 mg/kg) body weight (BW) once at allocation. Animals in the TULA group (10 multi-pen lots; 2036 animals) received a SC injection of tulathromycin (Draxxin®, Zoetis Mexico, S. De R.L. De C.V., Ciudad de Mexico) at a dosage of 1.1 mg/lb (2.5 mg/kg) BW once at allocation.

Animals in the ENRO group were shipped and slaughtered at an average of 270.4 DOF. Animals in the TULA group were shipped and slaughtered at an average of 270.9 DOF.

Data were analyzed using the GLIMMIX procedure of SAS® (Version 9.4, SAS Institute Inc, Cary, North Carolina) with the model containing the fixed effect of experimental group and the random effect of replicate nested within sex.

DOF = days on feed, SEM = standard error of the mean.

Although no differences were detected between the experimental groups for any of the outcome variables in the current study, which may reflect reality, it is also possible that the study could be underpowered to detect differences for each variable. As described in the Materials and Methods section, the study was powered to detect a 1.5% difference in overall mortality and a 3.0% difference in initial BRD treatment rate. The absolute differences observed between the experimental groups were 0.31% for overall mortality and 0.29% for the initial BRD treatment rate. Using overall mortality as an example, the a priori sample size calculations in the current study indicated that to detect differences of 1.0% or 0.5% in overall mortality would have required 20 or 73 replicates, respectively. Based on practical and economic impact considerations, it was decided to target 10 replicates of animals to find biologically relevant and economically important differences. Future studies will incorporate the baseline morbidity and mortality rates (and associated variance estimates) observed in the current study to refine sample size calculations for these types of studies.

Conclusions

In summary, no statistically significant differences were detected in any of the animal health or feedlot performance outcome variables when comparing the metaphylactic use of enrofloxacin or tulathromycin in mixed beef-breed feedlot bulls and heifers at HR of developing BRD in Mexico. Given the lack of detectable differences in any of outcome variables in the current study, the relative cost effectiveness of metaphylaxis programs utilizing enrofloxacin or tulathromycin should be dependent on the relative cost of each program, as well as any intangible attributes such as syringability, storage requirements, potential for antimicrobial resistance, etc. Additional research is warranted to determine the relative efficacy and cost effectiveness of enrofloxacin metaphylaxis programs in populations with higher baseline morbidity and mortality rates in Mexico.

Endnotes

[a] Baytril Max™ formula L.A., Bayer de Mexico, S.A. de C.V., Ciudad de Mexico, Mexico
[b] Draxxin®, Zoetis Mexico, S. De R.L. De C.V., Ciudad de Mexico
[c] Ganadero©, TopSolution 2015©, Monterrey, Nuevo Leon
[d] iFHMS, Feedlot Health Management Services, A Division of TELUS Agriculture Inc., Okotoks, Alberta
[e] Bovi-Shield Gold FP® 5, Zoetis Mexico, S. De R.L. De C.V., Ciudad de Mexico
[f] One Shot®, Zoetis Mexico, S. De R.L. De C.V., Ciudad de Mexico
[g] TSV-2®, Zoetis Mexico, S. De R.L. De C.V., Ciudad de Mexico
[h] Antrax-Vax, Lapisa, S.A. de C.V., Michoacan, Mexico
[i] Bayticol™ Plus Pour-On 1%, Elanco Salud Animal, S.A. de C.V., Jalisco, Mexico
[j] Synovex Choice®, Zoetis Mexico, S. De R.L. De C.V., Ciudad de Mexico
[k] Lutalyse®, Zoetis Mexico, S. De R.L. De C.V., Ciudad de Mexico
[l] Resflor®, MSD Salud Animal Mexico, Naucalpan de Juarez, Estado de Mexico
[m] Excede®, Zoetis Mexico, S. De R.L. De C.V., Ciudad de Mexico
[n] Microsoft® Office Excel 365 ProPlus, Microsoft Corporation, Redmond, Washington
[o] SAS® for Windows, Release 9.4, SAS Institute Inc., Cary, North Carolina
[p] Baytril® 100, Bayer Healthcare LLC, Shawnee Mission, Kansas
[q] Draxxin, Zoetis Inc., Kalamazoo, Michigan

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Conflict of interest

The authors declare no conflict of interest.

Author contributions

LOR, RDR, and CWB were involved in the conception and design of the study. LOR, AB, MGM, RNP, RDR, SJH, VEM, and CWB were involved acquisition of study data. LOR, CM, AB, RDR, SJH, and CWB were involved in analysis and interpretation of study data. All authors were involved in the manuscript drafting and/or revising process. All authors have approved the final version of this manuscript for publication.

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