

Original Article

Bovine respiratory disease complex associated mortality and morbidity rates in feedlot cattle from southeastern Brazil

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Abstract

Introduction: A feedlot is an intensive farming system for finishing livestock. Bovine respiratory disease (BRD) is a cause of morbidity and mortality in beef cattle, especially in feedlots.

Methodology: This study investigated the morbidity and mortality of BRD in a beef cattle feedlot in southeastern Brazil using: clinical diagnoses, therapy, morbidity, and mortality. Pulmonary fragments were collected from five steers, on feed from 3-32 days, with lesions of pneumonia for identification of BRD infectious agents PCR.

Results: 188,862 steers were on feed and morbidity was 7.05% (13,315/188,862), mortality 0.64% (1,214/188,862). The causes of morbidity were: BRD (6.13%), lameness (0.29%), trauma (0.21%), clostridiosis (0.13%) and polioencephalomalacia, PEM (0.12%). The causes of mortality were: BRD (0.21%), trauma (0.17%), and clostridiosis (0.13%). When all sick cattle were considered (n=13,315), BRD (86.9%) was the principal cause of morbidity, followed by lameness (4.13%), trauma (3.05%), and clostridiosis (1.82%). The cost of BRD-associated cattle mortality and morbidity was estimated at \$14,334.00/10,000 and \$16,315.40/10,000 respectively. It was projected that the economic effects due to BRD-associated morbidity in Brazil were \$6.31 million/annum, while losses due to mortality were \$5.54 million, resulting in an annual loss of \$11.85 million. Coinfections in cattle with pneumonia due to *Mannheimia haemolytica* and *Pasteurella multocida* were identified in 4/5 steers tested.

Conclusions: This is the first longitudinal study that investigated the incidence of BRD in feedlot cattle from Brazil, and the results herein described indicate that BRD contributed significantly to the development of mortality and morbidity of cattle on feed.

Key words: BRD complex, beef cattle, economic impacts, *Mannheimia haemolytica*, *Pasteurella multocida*.

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Introduction

In 2008 Brazil was recognised as one of the major exporters of beef worldwide, with 34.4 million cattle slaughtered in 2013 [1]; this represented 20% of all commercially produced beef worldwide [2]. Although a large proportion of the cattle reared in Brazil are done so exclusively on pastures, the use of feedlots for the intensive rearing of beef cattle has increased annually with approximately 3.87 million beef cattle on feed in 2012 [3]. The economic impacts associated with this management system of beef cattle production in Brazil is still to be investigated.

The bovine respiratory disease (BRD) complex is a multifactorial and multi-etiological entity that is associated with several infectious agents [4-6], coupled with cattle management [4], and environmental factors [4,7]. BRD is the most important cause of livestock mortality in the USA in feedlots and is responsible for

16% of all non-predator losses of beef cattle [8]. Data relative to the occurrence of BRD in Brazil is sparse, with *Histophilus somni* [9,10], the bovine respiratory syncytial virus, BRSV [10,11], bovine viral diarrhoea virus (BVDV), bovine coronavirus (BCoV), *Pasteurella multocida*, and *Mycoplasma bovis* [10] being identified as the principal contributory agents. However, there is no data relative to the economic impacts of BRD on beef cattle feedlots from Brazil. This study investigated the occurrence of defined conditions in a beef cattle feedlot from southeastern Brazil, with emphasis on the economic impacts associated with BRD.

Methodology

Study location and animals

This study was performed in a beef cattle feedlot located in the rural area of the city of Paracatu, in the

northeast of the State of Minas Gerais, southeastern Brazil. This feedlot has a stocking capacity of 50,000 head of cattle/season, represents one of the largest feed yards in Brazil, and uses microchipping so that all animals are chipped on entering and are monitored for routine production practices, indices, and clinical alterations. This feedlot consists of dystrophic Red Latosol (Oxisol) soil [12]. Due to this soil type, all pens are aspersed with water daily to reduce the amount of dust during the dry seasons.

Only steers between 24 to 36 months of age with initial average body weight (ABW) of 364 kg were included. All cattle at this feedlot were acquired from different geographical regions of the states of Minas Gerais, Goiás, and São Paulo, remained on feed for an average of 120 days until fattened to approximately 514 kg BW, with an average daily weight gain of 1.44 kg. All cattle were maintained in 356 fenced pens, each pen being 1,920m², and containing 140 animals, resulting in a carrying capacity of 13.7 steers/m². Cattle at this feedlot are supplemented via an automated system with a diet consisting of corn-based silage, flaked corn, cottonseed meal, and a commercial mineral salt; water is provided *ad libitum* in troughs derived from artesian wells supplied from natural reservoirs located on the farm.

All animals are immunized against bovine alphaherpesvirus-1 (BoHV-1), bovine viral diarrhoea virus (BVDV), bovine respiratory syncytial virus (BRSV), bovine parainfluenza virus type-3 (BPIV-3), clostridial diseases including tetanus, and *Pasteurella multocida* at the first day on entering the feedlot. A booster was not used and the previous vaccination history of the cattle in the study is unknown. At the same time, all animals are dewormed with a commercial product that has 15% albendazole (Agabendazol 15%, Agener União, São Paulo, SP, Brazil).

Data collection and characterization of BRD

This study was carried out from January 2013 to December 2014. Cattle at this feedlot are monitored daily by six veterinary technicians under the supervision of one veterinarian, who is responsible for the wellbeing of the feedlot. All steers with clinical manifestation of disease are immediately separated from the affected pen and examined by the on-site veterinarian. Data relative to clinical diagnoses, therapy, morbidity, and mortality are tabulated daily into a Microsoft Excel (2016) spreadsheet. This information was used as input data for the results of this study.

The evaluation used for the characterization of respiratory disease was based on the DART system (Zoetis, Florham Park, USA) with modifications [13]. In summary, the evaluated symptoms were depression, abnormal appetite, and/or respiratory distress. Manifestations of depression included but were not restricted to depressed attitude, lowered head, glazed or sunken eyes, slow or restricted movement, arched back, difficulty standing or walking, knuckling of joints or dragging toes when walking, and stumbling. Indication of abnormal appetite included animals that were completely off feed, eating less than expected or eating extremely slowly, a lack of gut fill or gaunt appearance, and obvious BW loss. Respiratory signs included difficult breathing, extended head and neck, and audible noise when breathing.

Clinical diagnoses were classified into seven large predetermined groups: BRD, feed refusal, clostridial diseases, lameness, bloat, trauma, and polyoencephalomalacia (PEM), which can also be divided based on management- (bloat, feed refusal, trauma, and lameness) or health-related conditions (BRD, clostridiosis, and PEM).

Economic impacts associated with BRD

An estimation of the economic impacts associated with BRD-related morbidity and mortality was determined by calculating the expenses associated with the following: cost per head of cattle that entered the feedlot due to vaccinations (\$1.2) and therapy (\$4); total operational cost per animal due to morbidity (\$21.4) and mortality (\$118.29); average value (\$558.86) per animal that died of BRD; and the number of animals affected. Operational costs included all expenses associated with the feeding and maintenance of each animal per day at the feedlot; all costs were expressed in USD.

We also were interested in estimating the effects of BRD on a national scale, but there was lack of adequate information from local databases. Notwithstanding this setback, an estimate was made based on available data to determine the economic effects of BRD on cattle managed on feedlots in Brazil. Consequently, we used the indices of morbidity and mortality identified during this investigation and projected the numbers on data available for the total effective herd of cattle reared on feed in Brazil during 2012.

Molecular characterization of infectious agents associated with BRD at this feedlot

Pulmonary fragments were randomly collected from five steers and used in PCR assays designed to identify common pathogens associated with BRD. These animals were on feed at the feedlot during 3-32 days, and all lungs had lesions of pneumonia.

Nucleic acids extracted from the pulmonary tissue as described [14], were used in PCR/RT-PCR assays designed to amplify specific genes of principal infectious agents associated with BRD. Bacterial pathogens targeted included: *H. somni* [15], *M. haemolytica* [16], and *P. multocida* [17]. Viral pathogens included BoHV-1 [18], BVDV [19], BPIV-3 [20], BCoV [21], and BRSV [22].

Positive controls included DNA/RNA from cell culture adapted Los Angeles strain of BoHV-1 [18] and the NADL strain of BVDV. DNA/RNA of *H. somni* [23], BPIV-3, BCoV, and BRSV [10] were obtained from previous studies. Nuclease-free water was used as negative controls in all PCR/RT-PCR assays. PCR products were separated by electrophoresis in 2% agarose gels, stained with ethidium bromide, and examined under ultraviolet light.

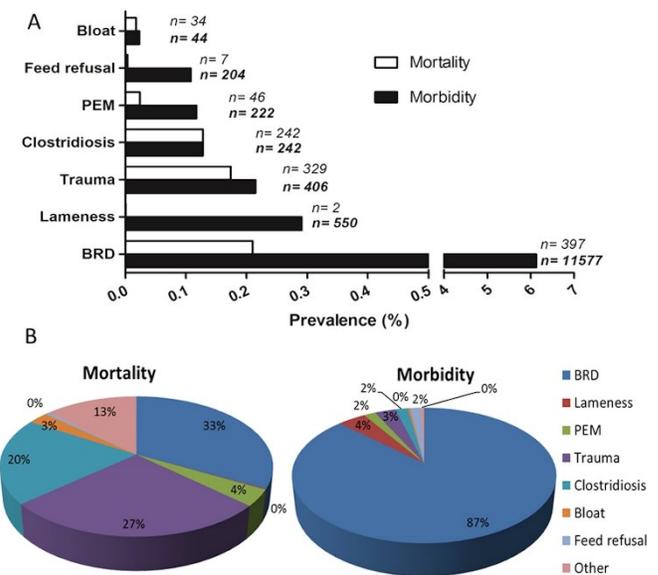
The amplified PCR products were then purified (PureLink Quick Gel Extraction & PCR Purification Combo Kit, Life Technologies, Carlsbad, USA) and submitted for direct sequencing using the forward and reverse primers. Sequencing was performed by using a BigDye Terminator v3.1 Cycle Sequencing Kit (BigDye Terminator v3.1 Cycle Sequencing Kit, Applied Biosystems, Carlsbad, USA) in a 3500 Genetic Analyzer (3500 Genetic Analyzer for Resequencing & Fragment Analysis, Applied Biosystems, Carlsbad, USA) sequencer.

Results

Morbidity and mortality rates

During this period, 188,862 head of cattle were confined at the feedlot. The morbidity rate was 7.05% (13,315/188,862), while mortality was estimated at 0.64% (1,214/188,862). Most (86.9%; 11,577/13,315) of the sick animals developed BRD (Figure 1a); respiratory disease was the main (6.13%; 11,577/188,862) cause of morbidity, followed by lameness (0.29%; 550/188,862), trauma (0.21%; 406/188,862), clostridiosis (0.13%; 242/188,862), and polioencephalomalacia, PEM (0.12%; 222/188,862). BRD (0.21%; 397/188,862) was the main cause of mortality at this feedlot (Figure 1a). This was followed by trauma (0.17%; 329/188,862), clostridiosis (0.13%; 242/188,862), other diseases (e.g., tumors, septicemia,

Figure 1. The distribution of principal disease conditions observed at the feedlot during the evaluation period, considering all animals. (A) Number of each condition plotted on the X axis as prevalence and (B) as the percentage of sick animals.



(PEM is polioencephalomalacia).

babesiosis, brisket edema, hepatic photosensitization, and hardware disease) (0.08/157/188,862), and PEM (0.02%; 46/188,862), these conditions were responsible for 32.7% (397/1,214), 27.1% (329/1,214), 19.9% (242/1,214), 12.9% (157/1,214) and 3.79% (46/1,214) of the animals that died during this period, respectively (Figure 1b). BRD was the principal cause of morbidity when all sick animals were considered, being responsible for 86.9% (11,577/13,315) of all cattle with any disease condition (Figure 1b); other important causes of morbidity were lameness 4.13% (550/13,315), trauma 3.05% (406/13,315), and clostridiosis 1.82% (242/13,315). In addition, all animals diagnosed with clostridial diseases died.

When the distribution of the frequency of morbidity related to BRD was evaluated, it was observed that 69.3% (8,027/11,577) of the cases occurred in cattle during the first 15 days on feed, while almost all (95.8%, 11,087/11,577) cases occurred during the first 30 days on feed (Figure 2a). Alternatively, the distribution of the frequency of mortality due to BRD was uniform during the days all cattle were on feed. Only 20.2% (80/397) of all deaths occurred during the first 15 days, 73.8% (293/397) within one month and 89.9% (357/397) in 60 days on feed (Figure 2b).

Table 1. Estimated costs associated with the mortality and morbidity of feedlot cattle due to bovine respiratory disease.

Estimated costs	Mortality (USD/animal)	Morbidity (USD/animal)
Vaccinations	1.22	1.22
Therapy	4.0	4.0
Average operational costs/animal	118.29	21.4
Average value of animal	558.86	-
Cost/animal	682.40	26.62
Number of animals/10,000 cattle	21	612
Total/100,000 cattle	14,334.00	16,315.40

Table 2. Projected estimates of the economic impacts of bovine respiratory disease on cattle on feed in Brazil.

Indices		Estimates for 2012	Cost (USD)
Cattle on feed ^a		3,866,531.00	
BRD Morbidity ^b	6.13%	237,018.35	
BRD Mortality ^b	0.21%	8,119.71	
Cattle herd ^c		211,279,082	
Cattle slaughtered ^c		31,118,740	
% cattle on feed		1.83	
% cattle slaughtered		12.43	
Morbidity cost/animal ^b	26.62		6,309,428.48
Mortality cost/animal ^b	682.4		5,540,893.58

^a Associação Nacional dos Confinadores (ASSOCON); ^b This study; ^c Instituto Brasileiro de Geografia e Estatística (IBGE).

Table 3. Results of molecular investigations of pathogens associated with bovine respiratory disease.

Animal	Days on Feed	Pathogens associated with bovine respiratory disease							
		<i>Mannheimia haemolytica</i>	<i>Pasteurella multocida</i>	<i>Histophilus somni</i>	BoHV-1	BPIV-3	BRSV	BVDV	BCoV
1	3	+	-	-	-	-	-	-	-
2	4	+	+	-	-	-	-	-	-
3	15	+	+	-	-	-	-	-	-
4	29	+	+	-	-	-	-	-	-
5	32	+	+	-	-	-	-	-	-

+, positive; -, negative; BoHV-1, bovine alphaherpesvirus-1; BPIV-3, bovine parainfluenza virus-3; BRSV, bovine respiratory syncytial virus; BVDV, bovine viral diarrhoea virus; BCoV, bovine coronavirus.

Economic impacts

The costs associated with vaccinations and therapy were estimated per animal at \$1.22 and \$4, respectively. The average operational cost related to mortality was \$118.29, being considerably more elevated than the \$21.4 associated with the maintenance of a sick animal. The estimated loss associated with mortality due to BRD was \$682.4/animal, resulting in accumulated losses of \$14,334.00 per 10,000 cattle on feed (Table 1). The expenses due to BRD-related morbidity was almost equal to the amount estimated for mortality, the cost per animal was \$26.62 with an overall loss of \$16,315.40 per 10,000 cattle on feed. Consequently, the total economic loss due to BRD was \$30,649.4 per 10,000 cattle on feed.

The number of cattle on feed in Brazil during 2012 represented 1.83% (3,866,531/ 211,279,082) of the total number of cattle reared and 12.43% (3,866,531/ 31,118,740) of all cattle slaughtered (Table 2). Further, an estimated projection of the economic impacts due to BRD in Brazil revealed that the cost associated with morbidity was \$6,309,428.48, while losses due to mortality were \$5,540,893.58; consequently, the overall projected cost of BRD in Brazil was \$11,850,322.06/annum.

Infectious agents associated with BRD

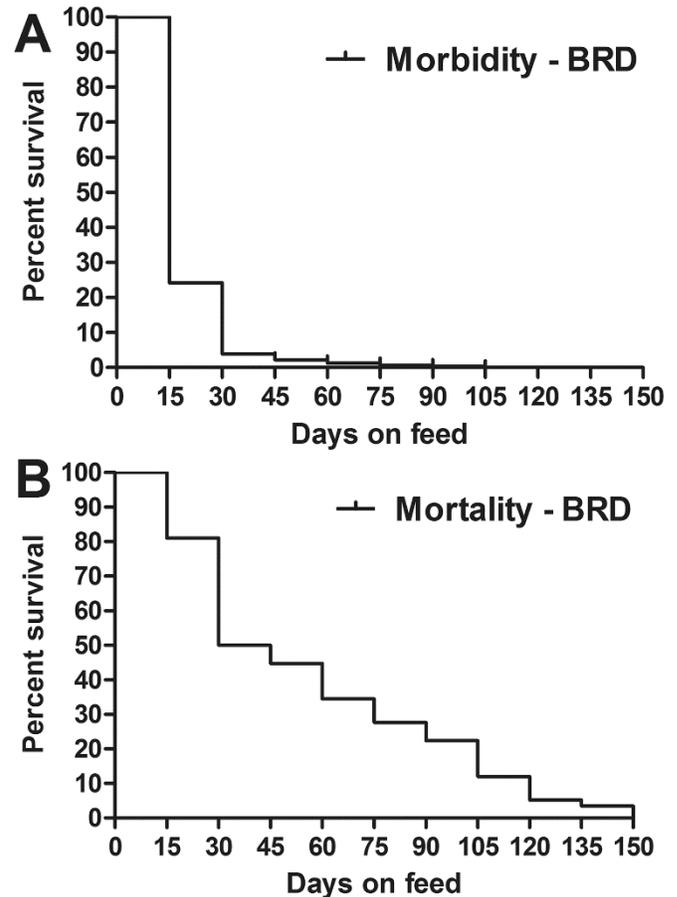
The distribution of the infectious agents identified from the pulmonary fragments of the steers is given in Table 3. Most of the steers tested were concomitantly infected by *M. haemolytica* and *P. multocida* ($n=4$), one was infected only by *M. haemolytica*; other infectious agents investigated were not identified.

Discussion

This is the first longitudinal study that estimated the impact of BRD-related morbidity and mortality on a beef cattle feedlot from Brazil. The information herein obtained is of fundamental importance to guide and alert local beef cattle producers on the importance of curbing expenses associated with BRD, since there was no available data that considered the peculiarities associated with feedlot cattle production in Brazil. Consequently, the data contained in this study can be compared with those of similar investigations done in North America [24-28], where the impacts due to BRD-related disease are well established [6].

The frequency of morbidity and mortality of beef cattle has been intensively investigated in North America primarily due to the elevated costs associated with the maintenance of cattle in feedlots. Additionally, it is of paramount importance to identify the infectious

Figure 2. (A) Distribution of the morbidity (n , 11,577) and (B) mortality (n , 397) associated with bovine respiratory disease relative to the days on feed.



agents and associated diseases of the BRD complex [29,30], as well as to evaluate and establish adequate control and preventative methods [30,31], implement efficient therapeutic and metaphylactic strategies [32,33]. Recently, models have been developed to estimate the risks of BRD occurring in feedlot cattle [28,34,35]. Although Brazil is one of the world's largest beef producer [2], these data are not available and their absence reinforces the importance of the information derived from this investigation. Consequently, this study has demonstrated that the amount of cattle (3.87 million head) on feed in Brazil during 2012 represented only 1.83% of the total bovine herd and 12.43% of all slaughtered cattle [36], indicating that although a relatively small proportion of cattle reared are maintained on feed, these formed a significant portion of the cattle slaughtered.

This investigation estimated morbidity and mortality at the feedlot were 7.05% and 0.64%, respectively. A study that evaluated the mortality trends of cattle at feedlots in the USA during 1994 to 1999

revealed an average mortality rate of 1.26% [37], while another study done during 1990 to 1993 revealed mortality rates that varied between 0.18% to 0.47% [38]. Consequently, the mortality rate observed at the Brazilian feedlot seems to be similar to those observed in North America.

BRD was the principal cause of mortality and morbidity during this investigation. Cattle morbidity and mortality due to BRD was 6.13% (11,577/188,862) and 0.21% (397/188,862), respectively; the mortality rate herein observed is less than the 0.7% described in a Oklahoma feedlot study [39], while BRD-related morbidity rates from North America have been calculated at 8.17% [40], 14.7% [39], and 20.6% [24].

Trauma was the second cause of mortality and represented 27.1% (329/1,214) of all animals that died during this period. One of the factors related to the elevated large percentage of mortality associated with trauma might be the fact that a large proportion of animals were transported from areas 700 km distant from the feedlot. This is because many animals delivered from cities within the states of Minas Gerais, Goiás, and São Paulo, developed multiple traumatic injuries and were euthanized. The distance travelled by feedlot cattle was associated with mortality, elevated BRD morbidity, and can serve as a predictor of cattle health and performance [41]. In addition, other factors associated with transported-related mortality, such as weight loss, and the stocking density and time without feed during transport [4,42,43], might have also contributed to the large percentage of trauma mortality observed during this study.

BRD was the most significant disease condition observed and represented 86.9% (11,577/13,315) of all sick animals at this feedlot; similar incidences (67-82%) of BRD were identified in Central USA [44]. Nevertheless, these results are more elevated than those described in a study from Ohio, with a morbidity rate of 20.6% [24], and the 17% incidence observed over a period of 15 years by the US Meat Animal Research Center [7]. When all dead animals were considered, mortality due to BRD was estimated at 32.7% (397/1214); these results are more elevated than the Ohio (5.9%) study [24], but are reduced when compared with the results (46-67%) described in Central USA [44], the Great Plains [38], and Ontario where mortality rates of 46-67% and 44.1%, and 69% [29], respectively, were described. Although there are differences in the level of BRD-related mortality, all studies suggest that BRD is a major cause of mortality at beef cattle feedlots. Consequently, these data demonstrate that BRD is an important cause of

mortality and morbidity at this feedlot with incidence levels compared to those described in the North America where there have been extensive and ongoing investigations of this important disease condition of cattle [6]. However, more investigations of the impact of BRD at feedlots from diverse cattle producing regions of Brazil are required to have an overall picture of the national effects of BRD on cattle herds. Alternatively, it was demonstrated that lesions associated with BRD have been underestimated and not considered as the principal disease that affects feedlot cattle, since pulmonary lesions only contributed to 8.3% of 1,617 animals slaughtered at a commercial abattoir in São Paulo [45].

Morbidity due to BRD was predominant (69.3%; 8,027/11,577) during the first 15 days on feed at this feedlot and by the end of 30 days most (95.8%; 11,087/11,577) animals were affected. These findings are in accord with the results described in Alberta [46,47], Ontario [29], and the Central USA [44], where the occurrence of pneumonia in feedlot cattle was more frequent during the first 10-15 days on feed. The occurrence of BRD in feedlot cattle during the first few days on feed seems to be common throughout the USA [37]. Hence, since BRD is a multifactorial and multi-etiological entity that results in the disequilibrium between the defense system of the host, the action of a wide variety of infectious agents, environmental and genetic factors, and stressors [5,7,42], it is likely that this disease entity will contribute significantly to beef cattle morbidity in feedlots throughout Brazil. The elevated incidence of BRD observed during this study can also be associated with the comingling of animals derived from diverse geographical locations and the diet adaptations during entry into feedlots [43]. In addition, these animals were not on any metaphylactic therapy.

The total cost associated with therapy of an animal with BRD was \$26.62, being similar to the \$23.6 USD related with the treatment of animals with respiratory disease from the USA [48], but less than the \$12.39/steer reported in a 1999 Iowa State University study [24]. Nevertheless, the \$1.22 and \$4/head spent on vaccinations and therapy, were similar to those described (\$1 and \$3, respectively) in a three year period of the Ontario study [27]. Although the cost of losing an animal at this feedlot due to BRD was determined at \$682.4, the projected cost associated with morbidity due to BRD in Brazil was \$6.31 million/annum. It must be highlighted that this number is not entirely accurate since this value was derived from several databases computed in 2012 and the

indices determined during this investigation. Nevertheless, this is the first estimated projection of the nationwide effects of BRD on confined cattle reared in Brazil, and provides an insight of the approximate economic impacts of BRD on the local beef industry, using the indices determined during this investigation as baseline input data. Although the annual estimated cost identified during this study is below the \$750 million that is associated with BRD in the USA [25], the amount of cattle on feed in the USA is comparatively more elevated than in Brazil, so the value herein described should not be underestimated. However, the projected total economic loss (\$11.85 million) due to BRD will affect the local beef cattle producing industry, considering that this amount represented only 1.83% of all cattle reared in Brazil.

The identification of pathogens associated with BRD in Brazil is incipient. Although BRSV was identified in several feedlots from the state of Rio Grande do Sul [11], these authors only investigated the occurrence of this viral pathogen. Recently, our group has identified single and mixed associations of *H. somni* with bovine alphaherpesvirus-1 in feedlot cattle with BRD from northern Paraná [9], and coinfections of *H. somni* with BRSV in feedlot cattle from the state of São Paulo [49]. We have also identified coinfections due to several disease agents such as BRSV, BVDV, BCov, *P. multocida*, *M. bovis*, and *H. somni* in dairy cattle from the state of Paraná [10]. During this study, concomitant bacterial infections due to *M. haemolytica* and *P. multocida* were detected in the lung of steers with bronchopneumonia, suggesting that these pathogens may be endemic at this feedlot. These results are quite different from those of other studies done in Brazil [9-11, 49], and in beef cattle feedlots from Oklahoma, USA [39], Ontario, Canada [29], and in dairy herds from Quebec, Canada [50] in which there were coinfections with viral and bacterial pathogens and the viral pathogens probably predisposed the animals to a secondary bacterial disease. Therefore, we suggest that the bacterial pathogens at this feedlot were most likely associated with other stresses, such as vaccination and transport, since these pathogens were identified in steers that were less than 32 days-on feed. Furthermore, metaphylactic strategies were not implemented during the period investigated at this feedlot, which can also contribute to the occurrence of bacterial pneumonia in animals that were on feed for 3-32 days. However, a more detailed investigation is needed to understand the dynamics of the pathogens associated with BRD at this feedlot so that adequate

prophylactic and/or metaphylactic measures can be implemented.

Conclusions

This study has demonstrated that morbidity and mortality rates associated with bovine respiratory disease at this feedlot were comparable to those described in feedlots from North America. In addition, the economic findings suggest that BRD can impact significantly the local livestock industry. Moreover, only bacterial agents were associated with BRD at this feedlot.

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