DOI: 10.5433/1679-0359.2016v37n5Supl2p3589

Epidemiological situation of bovine tuberculosis in the state of Mato Grosso, Brazil

Situação epidemiológica da tuberculose bovina no Estado de Mato Grosso, Brasil

João Marcelo Brandini Néspoli[1]; Rísia Lopes Negreiros[1]; Marcos Amaku[2]; Ricardo Augusto Dias[2]; Fernando Ferreira[2]; Evelise Oliveira Telles[2]; Marcos Bryan Heinemann[2]; José Henrique Hildebrand Grisi-Filho[2]; Vitor Salvador Picão Gonçalves[3]; José Soares Ferreira Neto[2*]

Abstract

In 2009, the epidemiological situation of bovine tuberculosis was studied in the state of Mato Grosso, which is a traditional beef exporter. The state was divided into four regions. In each region, properties were selected randomly. A predetermined random number of animals were chosen from these properties, and comparative cervical tuberculin tests were conducted. In total, 28,878 animals from 1,133 properties underwent examination. The animals with inconclusive results were reexamined with the same diagnostic procedure in a minimal interval of 60 days. In each sampled property, a questionnaire-based survey was conducted to identify possible risk factors for the disease. In the state, the prevalence of infected herds and animals was 1.3% [0.7; 2.4] and 0.12% [0.03; 0.44], respectively. Further, the prevalence of infected herds and animals were 0.0% [0.0; 2.0] and 0.0% [0.0; 0.08] in the Pantanal region, 1.3% [0.5; 3.1] and 0.04% [0.01; 0.17] in the dairy region, 0.7% [0.2; 2.7] and 0.01% [0.003; 0.04] in the fattening region, and 1.7% [0.7; 4.1] and 0.24% [0.06; 0.90] in the breeding region, respectively. It was observed that the condition of the herds infected with bovine tuberculosis was associated with milk production, European or mestizo breeds, degree of sophistication in the production mode, and herd size of up to 486 animals. Therefore, the implementation of a monitoring system for detection and elimination of the residual infected herds along with incorporation of risk-based monitoring elements is the best strategy for the state.

Key words: Brazil. Bovine tuberculosis. Mato Grosso. Prevalence. Risk factors.

Resumo

Em 2009, a situação epidemiológica da tuberculose bovina foi estudada no Estado de Mato Grosso, tradicional exportador de carne. O Estado foi estratificado em quatro regiões. Em cada região, propriedades foram sorteadas aleatoriamente e, dentro dessas, escolheu-se de forma também aleatória um número pré-estabelecido de animais, os quais foram submetidos ao teste tuberculínico Cervical

[1] Médicos Veterinários, Instituto de Defesa Agropecuária do Estado de Mato Grosso, Cuiabá, MT, Brasil. E-mail: joao.brandini@uol.com.br; risianegreiros@yahoo.com.br

[2] Profs., Faculdade de Medicina Veterinária e Zootecnia, Universidade de São Paulo, USP, São Paulo, SP, Brasil. E-mail: grisi@vps.fmvz.usp.br; fernando@vps.fmvz.usp.br; amaku@vps.fmvz.usp.br; dias@vps.fmvz.usp.br; evelise@vps.fmvz.usp.br; marcosbryan@usp.br; jsoares@vps.fmvz.usp.br

[3] Prof., Faculdade de Agronomia e Medicina Veterinária, Universidade de Brasília, UNB, Brasília, DF, Brasil. E-mail: vitorspg@unb.br

[*] Author for correspondence

Received: Sept. 20, 2016 – Approved: Sept. 20, 2016

Comparativo. No total, foram testados 28.878 animais, provenientes de 1.133 propriedades. Os animais que resultaram inconclusivos foram retestados com o mesmo procedimento diagnóstico em intervalo mínimo de 60 dias. Em cada propriedade amostrada aplicou-se um questionário para se verificar possíveis fatores de risco para a doença. No Estado, a prevalência de focos foi de 1,3% [0,7; 2,4] e a de animais 0,12% [0,03; 0,44]. Nas regiões, as prevalências de focos e de animais foram, respectivamente, de 0,0% [0,0; 2,0] e 0,0% [0,0; 0,08] na região pantanal, 1,3% [0,5; 3,1] e 0,04% [0,01; 0,17] na região leite, 0,7% [0,2; 2,7] e 0,01% [0,003; 0,04] na região engorda e 1,7% [0,7; 4,1] e 0,24% [0,06; 0,90] na região cria. Verificou-se que a condição do foco de tuberculose bovina está associada à produção de leite, com raças europeias ou mestiças, com algum grau de sofisticação no modo de produção e em rebanhos com até 486 animais. Assim, a implementação de um sistema de vigilância para detecção e saneamento dos focos residuais constitui a melhor estratégia para o Estado.
Palavras-chave: Brasil. Fatores de risco. Mato Grosso. Prevalência. Tuberculose bovina.

Introduction

Located in the Central-West Region of Brazil, the state of Mato Grosso (MT) is the third largest federative unit in the country with a land area of 903,358 square kilometers that represents 9.4% of the national territory (BRASIL, 2002). According to the Census 2010, 3 million people reside in the state that accounts for 1.6% of the Brazilian population (BRASIL, 2011a). It consists of three biomes: the Amazon, Cerrado, and Pantanal, which occupy 53%, 40%, and 7% of the territory, respectively. The Amazon biome, located in the north and southwest portions of the state, has forest vegetation predominantly. The Cerrado biome in the central area includes forests and mainly savanna formations, while the Pantanal biome in the south comprises savanna formations associated with forests and great species diversity, which typically has a flood pulse, including periods od flood and ebb. During the rainy season, large plain extensions are inundated; however, capons, mountain ranges, and higher landscape units remain dry (MATO GROSSO, 2009).

Cattle were introduced in the state during the colonial period, particularly in areas located in the Pantanal between the Taquari and Coxim rivers, which were favorable natural pastures in the region. Currently, the activity occupies about 74% of the state's productive land that totals to about 22 million hectares (BRASIL, 2006). In 2009, the state had approximately 27 million bovine animals; the beef cattle breed was predominant in an extensive regime, and the animals were distributed over 110,000 properties (www.ibge.gov.br, BRASIL, 2006).

According to the Ministry of Agriculture Livestock and Supply (MAPA), 5 million cattle were slaughtered in MT in 2012, which accounts for 21% of the total slaughtering processes conducted under the Federal Inspection Service in Brazil. In the same year, the state had nationwide lead in beef exports that accounted for 18% of the total exports by Brazil, which currently holds the first place in the international market. For the same period, the milk production represented only 2.2% of the total milk produced in Brazil.

From the health point of view, MT is a zone free of foot-and-mouth disease, and vaccination has been provided since 2000. Tuberculosis and brucellosis stand out among the problems that still plague the bovine meat and milk production chain in the state. In 2001, Brazil launched the National Program for Control and Eradication of Animal Brucellosis and Tuberculosis (PNCEBT) (LAGE et al., 2006) with methodologies in harmony with those recommended by the World Organization for Animal Health (OIE) based on vaccination against brucellosis, certification of properties by routine indirect testing, and monitoring systems for areas in the eradication phase. In this context, the MT has already conducted a study on the epidemiological situation of brucellosis in 2002-2003 (NEGREIROS et al., 2009), which aimed to generate good quality

data to define the best strategies to combat the infection in the state.

Regarding tuberculosis, there are no well-established studies on the epidemiological status in the state, and the available data is limited to the convictions of carcasses in slaughterhouses and notifications of the positive results of tuberculin tests. Salazar (2005) reported that between 2004 and 2005, 0.05% of the bovine carcasses had suggestive lesions of tuberculosis. Between 2005 and 2010, 72 cattle with positive results of tuberculin tests were reported (MATO GROSSO, 2011a). According to a sanitary agreement that was signed with some beef importing countries (BRASIL, 2011b), it is mandatory to attempt *Mycobacterium bovis* isolation from samples collected in slaughterhouses qualified for beef exports. From 2009 to 2011, 26 cases of bovine tuberculosis were confirmed bacteriologically (MATO GROSSO, 2011b).

In Brazil, recent studies carried out in 12 States, which hold 62% of the Brazilian cattle population, showed prevalence of tuberculosis infected herds among 0.36% and 9.0%, in the Federal District and São Paulo state, respectively (BAHIENSE et al., 2016; BARBIERI et al., 2016; DIAS et al., 2016; GALVIS et al., 2016; GUEDES et al., 2016; LIMA et al., 2016; QUEIROZ et al., 2016; RIBEIRO et al., 2016; ROCHA et al., 2016; SILVA et al., 2016; BAUMGARTEN et al., 2016; VENDRAME et al., 2016).

Therefore, because the epidemiological status of bovine tuberculosis is not known adequately in the state of MT, the present study aimed to estimate the prevalence of infected herds and animals and explore the possible existence of regional differences. In addition, we intended to identify risk factors associated with the presence of infected herds.

Methods and Materials

The study design was conducted in collaboration with the Ministry of Agriculture, Livestock and Supply (MAPA), the Agricultural Protection Institute of the State of Mato Grosso (NDEA-MT), and the Collaborating Centre for Animal Health located in the Faculty of Veterinary Medicine and Animal Science (FMVZ), University of São Paulo (USP). Fieldwork was performed by veterinarians from INDEA-MT from April 2009 to December 2009.

In order to verify possible regional differences in both the prevalence of tuberculosis and risk factors involved, the state was divided into four regions with homogeneous characteristics. For this characterization, the different production systems, management practices, operating purposes, average herds sizes, and marketing system, as well as operational and logistical capacity of the official veterinarian service of the state to perform the field activities, as described in Negreiros et al. (2009), were taken into account.

A two-stage sampling was conducted in order to estimate of the prevalence of infected herds and animals in the regions and in the state. In the first stage, within each region, a predetermined number of properties with reproductive activity were randomly selected from properties registered by the INDEA-MT. In the second stage, within each property, a predetermined number of breeding female animals aged 24 months or more were selected. In properties where there were distinct herds, only the predominant one with the higher economic value or that considered as main objective of production was targeted in the study. The herd has been defined as a group of animals kept under the same management practices, that is, exposed to the same conditions of risk. The randomly selected properties, which for some reason could not be sampled, were replaced by a new draw. The numbers of selected properties per region were estimated by the formula for simple random sample (THRUSFIELD, 2007), according to the following parameters: estimated prevalence of 20%, confidence level of 95%, and error of 5%. In the Pantanal region, up to 10% error was admitted due to specific operational difficulties.

To draw the animals within each property, the number of bovine animals to be examined was calculated in order to classify them as an infected or tuberculosis-free herd, considering aggregate sensitivity values greater than or equal to 85% and aggregate specificity equal to or higher than 95%. Individual sensitivity and specificity values of 80% and 99.5% were adopted respectively. The calculations were performed with the aid of Herdacc program version 3.0.

In properties with up to 99 breeding cows, aged 24 months or more, 20 were examined. Meanwhile, in properties with 100 or more, 40 were examined. These animals were always selected randomly, and those, which had delivered in the period of 15 days before or after, were replaced.

The sampled animals underwent comparative cervical tuberculin tests, which were conducted in accordance with the Technical Manual of the National Program for Control and Eradication of Brucellosis and Tuberculosis (LAGE et al., 2006). To exclude dubious results by the end of the study, those animals with inconclusive results were reexamined with the same diagnostic procedure in a minimum interval of 60 days. All animals that tested positive were euthanized.

The occurrence of one animal with a positive result was enough to classify the properties with up to 20 animals tested as an infected. For those, which have tested 40 animals, it took at least two positive animals to declare them as an infected.

For each region and throughout the state, the prevalence of infected herds and animals for bovine tuberculosis were obtained. The prevalence of infected herds within each region was also stratified by the type of farming. The apparent prevalence and confidence intervals calculations were performed as recommended by Dean et al. (1994). Calculations referring to the prevalence of infected herds and animals in the state and the animal prevalence within the regions were performed in weighted form (DOHOO et al., 2003). The weight of each property in calculating the prevalence of infected herds in the state was given as follows:

$$P_1 = \frac{\text{properties with reproductive activity in the region}}{\text{properties with reproductive activity sampled in the region}}$$

The weight of each animal in the calculation of the prevalence of animals in the state was given by:

$$P_2 = \frac{\text{cows} \geq 24 \text{ months in the property}}{\text{cows} \geq 24 \text{ months sampled in the property}} \text{ X } \frac{\text{cows} \geq 24 \text{ months in the region}}{\text{cows} \geq 24 \text{ months sampled in the region}}$$

In the expression above, the first term refers to the weight of each animal in the calculation of animal prevalence within regions. The calculations were performed with the SPSS program, version 20.

In all the properties selected for the study, a questionnaire-based survey was conducted to identify risk factors associated with the presence of infected herds. The questionnaire was formulated to check for exposure to classical risk factors as described in the literature (MARANGON et al., 1998; RAMÍREZ-VILLAESCUSA et al., 2010; SCKUCE et al., 2012) and others of particular regional interest. The questions addressed the following variables: type of operation (beef, dairy or mixed); degree of agglomeration of animals (constrained, semi-constrained and extensive); number and breed of the animals; use of milking machine and artificial insemination; form of delivery of the milk; introduction of new bovine animals; presence of other animal species in the property (domestic and wild); existence of border with a forest; routine tests for bovine tuberculosis; the slaughter of breeding animals; sharing pastures, watery/drinking fountains, supplies, equipment and personnel; presence of marshy areas; feeding cattle with whey; and existence of veterinary care.

The variables were organized in order to be represented on an increasing scale of risk. A re-categorization of these variables was made when necessary. The lowest risk category was considered as a basis for comparison with the others. Quantitative variables were re-categorized into quartiles. A first exploratory data analysis (univariate) to select those with $p \leq 0.20$ based on the $\chi 2$ or Fisher's exact test was conducted, and subsequently, logistic regression analysis was performed as recommended by Hosmer and Lameshow (1989). The calculations were performed with SPSS, version 20. All the information generated by the fieldwork was included in a specific database, and were used in epidemiological analyses.

Results

The state was divided into four regions, and the boundaries are shown in Figure 1. The Pantanal region consists in large areas affected annually by flood pulses and the breeding of cattle is extensive. In the dairy region, the Cerrado biome is predominant, where milk production is common. In the fattening region, the processes mainly aim at fattening cycles, and this practice is conducted between the Cerrado and the Amazon forest. The breeding region, where the reproduction cycle is more frequently conducted, is located in the Amazon forest biome.

Figure1. Map of the state of Mato Grosso divided by regions: Pantanal (1), dairy (2), fattening (3), and breeding (4). In the detail, the localization of the state in Brazil in 2009.

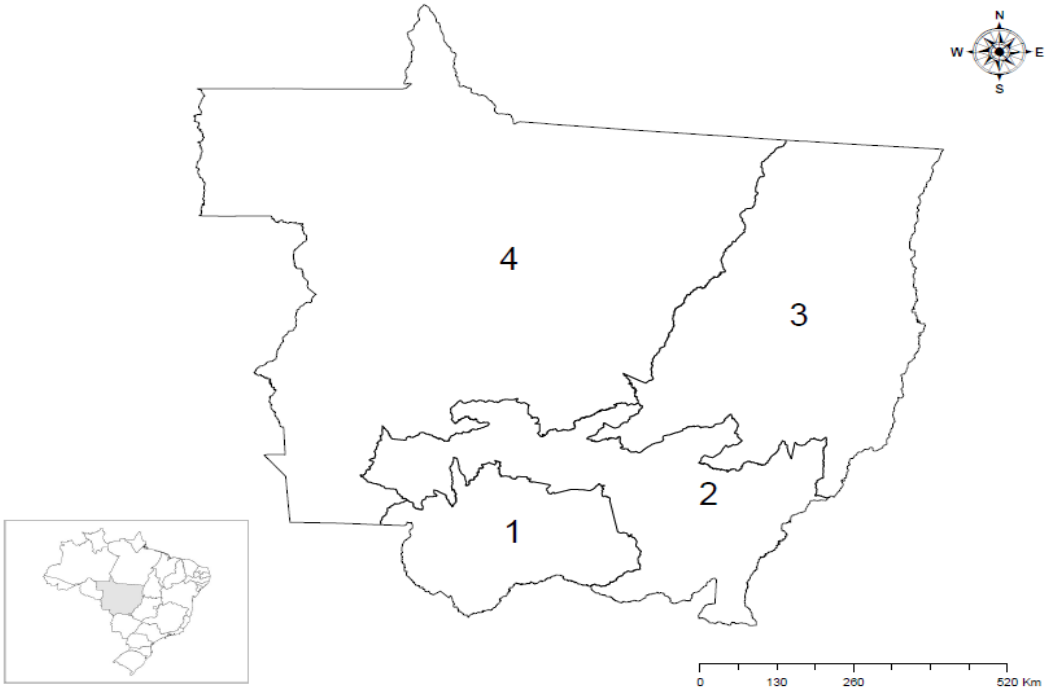

Table 1 presents a summary of the census data and samples studied. Among the 1,133 sample properties, 17 were excluded because it was not possible to conduct the tuberculin test within the prescribed period following the diagnostic procedure.

Table 1. Summary of census bovine data and details of the samples studied according to the regions of Mato Grosso, Brazil in 2009.

Region	Number of municipalities	Properties with breeding activities	Sampled properties	Cows aged ≥24 months	Sampled cows aged ≥24 months
1 - Pantanal	6	6,836	146	1,021,778	3,938
2 - Dairy	50	22,878	387	2,249,231	9,462
3 - Fattening	27	17,967	302	2,885,960	7,933
4 - Breeding	58	45,615	298	5,486,549	7,545
Total	141	93,296	1,133	11,643,518	28,878

Source: Secretary of Rural Development and Family Agriculture, Institute of Agriculture Defense of the state of Mato Grosso (INDEA/MT) in 2009.

Table 2 shows the results of the prevalence of bovine tuberculosis among infected herds in the regions and the state. The prevalence of infected herds based on the type of farming in the regions are presented in Table 3, and the prevalence of bovine tuberculosis for breeding cows are shown in Table 4. The median herd sizes for properties comprising beef, mixed, and milk-cattle types were 306, 160, and 51 bovine animals, respectively.

Table 2. Prevalence of herds infected with bovine tuberculosis according to the regions of the state of Mato Grosso, Brazil in 2009.

Region	Properties		Prevalence (%)	CI 95% (%)
	Examined	Positive		
1 - Pantanal	146	0	0.0	[0.0; 2.0]*
2 - Dairy	387	5	1.3	[0.5; 3.1]
3 - Fattening	302	2	0.7	[0.2; 2.7]
4 - Breeding	298	5	1.7	[0.7; 4.1]
Mato Grosso	1,133	12	1.3	[0.7; 2.4]

Table 3. Prevalence of herds infected with bovine tuberculosis stratified by type of farming in the regions of Mato Grosso, Brazil in 2009.

3	Prevalence of herds infected with bovine tuberculosis (P) (%)					
	Beef Cattle		Dairy		Mixed	
	P (%) (positive/ sampled)	CI 95% (%)	P (%) (positive/ sampled)	CI 95% (%)	P (%) (positive/ sampled)	CI 95% (%)
1 - Pantanal	0.0 (0/94)	[0.0; 3.1]*	0.0 (0/28)*	[0.0; 9.8]	0.0 (0/23)	[0.0; 11.7]*
2 - Dairy	0.0 (0/157)	[0.0; 1.9]*	2.7 (4/148)	[1.0; 7.0]	1.3 (1/76)	[0.2; 8.8]
3 - Fattening	0.0 (0/209)	[0.0; 1.4]*	2.1 (1/ 47)	[0.3;13.7]	2.4 (1/42)	[0.3; 15.1]
4 - Breeding	0.6 (1/161)	[0.1; 4.3]	3.2 (3/94)	[1.0; 9.5]	2.8 (1/36)	[0.4; 17.3]

*Calculations performed using the Monte Carlos method and beta distribution.

Table 4. Prevalence of cows positive for tuberculin test according to the regions of the state of Mato Grosso, Brazil in 2009.

Region	Cows		Prevalence (%)	CI (95%) (%)
	Examined	Positive		
1 - Pantanal	3,938	0	0.000	[0.000; 0.076]*
2 - Dairy	9,462	12	0.037	[0.008; 0.168]
3 - Fattening	7,933	3	0.010	[0.003; 0.043]
4 - Breeding	7,545	8	0.240	[0.064; 0.904]
Mato Grosso	28,878	23	0.123	[0.034; 0.440]

*Calculations performed using the Monte Carlos method and beta distribution.

Table 5 shows the results of the univariate analysis. A good final logistic regression model could not be developed because of detection of a small number of cases (12 infected herds). Thus, the multivariate analysis was abandoned, and only the variables with a value of $p \leq 0.05$ based on the $\chi 2$ test are shown in Table 5.

Table 5. Results of univariate analysis of potential risk factors for bovine tuberculosis ($p \leq 0.05$) in Mato Grosso, Brazil in 2009.

Continue ...

Variables and categories	Pos.	Total	%	p
Kind of exploration				0.003
Beef Cattle	1	621	0.2	
Dairy	8	317	2.5	
Mixed	3	177	1.7	
Delivery of milk				0.006
No	3	717	0.4	
Yes	9	399	2.3	
Predominant bovine breed				0.011
Zebu Cows	2	682	0.3	
European dairy	1	21	4.8	
European beef	0	6	0.0	
Mestizo	9	395	2.3	
Other breeds	0	8	0.0	
Kind of milking in dairy or mixed properties				<0.001
No milking	0	564	0.0	
Mechanical in a room	3	17	17.6	
Mechanical in the foot	0	22	0.0	
Manual	9	509	1.8	
Number of milkings				<0.001
No milking	0	559	0.0	
One milking	11	504	2.2	
Two or three milkings	1	42	2.4	
Cooling of the milk				0.018
No	7	959	0.7	
Yes	5	157	3.2	

... Continuation

Delivery of the milk in bulk				0.005
No	6	945	0.6	
Yes	6	171	3.5	
Total number of bovines (Quartis)				0.028
1 a 55	3	282	1.1	
56 a 141	2	276	0.7	
142 a 486	7	279	2.5	
487 a 16.957	0	279	0.0	

Discussion and Conclusions

The prevalence of bovine tuberculosis infected herds in the state of Mato Grosso was estimated at 1.3% [0.7; 2.4%] equal to that observed in the states of Bahia, Paraná, Santa Catarina, Rio Grande do Sul, Mato Grosso do Sul, Rondonia, Goiás, Pernambuco, and the Federal District, and lower than those observed in São Paulo, Espírito Santo, and Minas Gerais (BAHIENSE et al., 2016; BARBIERI et al., 2016; DIAS et al., 2016; GALVIS et al., 2016; GUEDES et al., 2016; LIMA et al., 2016; QUEIROZ et al., 2016; RIBEIRO et al., 2016; ROCHA et al., 2016; SILVA et al., 2016; BAUMGARTEN et al., 2016; VENDRAME et al., 2016).

In Mato Grosso, although differences in the prevalence of infected herds between regions were not observed, the results suggest a higher concentration of the disease in the dairy and breeding regions (Table 2). The association between bovine tuberculosis and dairy farming was observed by several authors in Brazil and abroad (GALVIS et al., 2016; BAHIENSE et al., 2016; BARBIERI et al., 2016; DIAS et al., 2016; QUEIROZ et al., 2016; ROCHA et al., 2016; SILVA et al., 2016; BAUMGARTEN et al., 2016; PEREZ et al., 2002; PORPHYRE et al. 2008; RAMÍREZ-VILLAESCUSA et al., 2010; ZENDEJAS-MARTÍNEZ et al., 2007, 2008), and this can be attributed to factors inherent to this type of operation, described as predisposing to the disease, such as high density (CLEAVELAND et al., 2007; HUMBLET et al., 2010; OLIVEIRA et al., 2008) and longer production cycle (BIFFA et al., 2011; REGASSA et al., 2010).

The data in Table 3 also suggest a strong tendency of bovine tuberculosis to concentrate in dairy or mixed farms in Mato Grosso.

In the state, the prevalence of tuberculosis in animals was estimated at 0.12% with homogeneity among regions, with the exception of the fattening region, where the result was statistically lower than the breeding region (Table 4). This can be explained by the higher proportion of beef cattle properties in this region (70%) when compared to the others: Pantanal (65%), dairy (41%), and breeding (55%). The prevalence in animals is among the lowest recorded in recent studies conducted in the Brazilian states mentioned above.

The small number of cases (12 infected herds) prevented the realization of a multivariate logistic regression analysis for individualization of risk factors. Thus, the study was limited to the verification of associations ($\chi 2$) between the variables and the tuberculosis infection of the herds.

Table 5 indicates that the tuberculosis infection is associated with milk production by European or mestizo animal races, with some degree of sophistication in the production mode (mechanical milking, milk cooling, and bulk delivery), and herd size of up to 486 animals. As mentioned above, many authors have reported an association between bovine tuberculosis and dairy farming. In Brazil, an association between bovine tuberculosis and the sophistication in milk was reported in the States of Minas Gerais, São Paulo, Paraná and Goiás (BELCHIOR et al., 2016, DIAS et al., 2016; ROCHA et al., 2016; SILVA et al., 2016).

In conclusion, in the state of MT, the prevalence of bovine tuberculosis in both infected herds and animals is low, and the infection is more concentrated in properties with dairy farming, particularly those of high production and greater sophistication in the production mode. In this scenario, implementation of a surveillance system for detection and elimination of residual infected herds, incorporating risk-based surveillance elements, is the best strategy for the state.

Acknowledgements

The authors acknowledge the logistical and financial support from MAPA, INDEA-MT, CNPq and FAPESP.

References

BAHIENSE, L.; ÁVILA, L. N. de; BAVIA, M. E.; AMAKU, M.; DIAS, R. A.; GRISI-FILHO, J. H. H.; FERREIRA, F.; TELLES, E. O.; GONÇALVES, V. S. P.; HEINEMANN, M. B.; FERREIRA NETO, J. S. Prevalence and risk factors for bovine tuberculosis in the State of Bahia, Brazil. *Semina: Ciências Agrárias,* Londrina, v. 37, n. 5, p. 3549-3560, 2016. Suplemento 2.

BARBIERI, J. M.; OLIVEIRA, L. F.; DORNELES, E. M. S.; MOTA, A. L. A. A.; GONÇALVES, V. S. P.; MALUF, P. P.; FERREIRA NETO, J. S.; FERREIRA, F.; DIAS, R. A.; TELLES, E. O.; GRISI-FILHO, J. H. H.; HEINEMANN, M. B.; AMAKU, M.; LAGE, A. P. Epidemiological status of bovine tuberculosis in the state of Minas Gerais, Brazil. *Semina: Ciências Agrárias,* Londrina, v. 37, n. 5, p. 3531-3548, 2016. Suplemento 2.

BELCHIOR, A. P. C.; LOPES, L. B.; GONÇALVES, V. S. P.; LEITE, R. C. Prevalence and risk factors for bovine tuberculosis in Minas Gerais State, Brazil. *Tropical Animal Health and Production*, Edinburgh, v. 48, n. 2, p. 373-378, 2016.

BIFFA, D.; INANGOLET, F.; BOGALE, A.; OLOYA, J.; DJØNNE, B.; SKJERVE, E. Risk factors associated with prevalence of tuberculosis-like lesions and associated mycobacteria in cattle slaughtered at public and export abattoirs in Ethiopia. *Tropical Animal Health and Production*, Edinburgh, v. 43, n. 2, p. 529-538, 2011.

BRASIL. Ministério da Agricultura Pecuária e Abastecimento. Secretaria de Defesa Agropecuária. Departamento de Inspeção de Produtos de Origem Animal/Departamento de Saúde Animal. Fax Circular Conjunto DIPOA/ DSA 001/2011. Revoga o Fax Circular Conjunto CGAL/DIPOA/DSA 001 de 11 de fevereiro de 2009. Brasília, 1 jul. 2011b.

_____. Ministério do Planejamento, Orçamento e Gestão. Instituto Brasileiro de Geografia e Estatísticas. *Censo Agropecuário 2006:* Brasil, Grandes Regiões e Unidades da Federação. Rio de Janeiro: IBGE, 2006. 777 p.

_____. Ministério do Planejamento, Orçamento e Gestão. Instituto Brasileiro de Geografia e Estatísticas. Rio de Janeiro, 2002. Resolução nº 05, de 10 de outubro de 2002. *Diário Oficial [da] União,* nº 198, 11 out. 2002. Seção 1, p. 48-65.

_____. Ministério do Planejamento, Orçamento e Gestão. Instituto Brasileiro de Geografia e Estatísticas. *Sinopse do Censo Demográfico 2010*: Brasil, Grandes Regiões e Unidades da Federação. Rio de Janeiro: IBGE, 2011a. 261 p.

CLEAVELAND, S.; SHAW, D. J.; MFINANGA, S. G.; SHIRIMAD, G.; KAZWALA, R. R.; EBLATE, E.; SHARP, M. *Mycobacterium bovis* in rural Tanzania: Risk factors for infection in human and cattle populations. *Tuberculosis*, v. 87, n. 1, p. 30-43, 2007.

DEAN, A. G.; DEAN, J. A; COULOMBIER, D.; BRENDEL, K. A.; SMITH, D. C.; BURTON, A. H.; DICKER, R. C.; SULLIVAN, K.; FAGAN, R. F.; ARNER, T. G. *Epi Info 6*.: a word processing database, and statistics program for epidemiology on microcomputers. Atlanta: Center for Diseases Control and Prevention, 1994. 601 p.

DIAS, R. A.; STANOJLOVIC, F. M. U.; BELCHIOR, A. P. C.; FERREIRA, R. S.; GONÇALVES, R. C.; AGUIAR, R. S. C. B.; SOUSA, P. R.; SANTOS, A. M. A.; AMAKU, M.; FERREIRA, F.; TELLES, E. O.; GRISI-FILHO, J. H. H.; GONÇALVES, V. S. P.; HEINEMANN, M. B.; FERREIRA NETO, J. S. Prevalence and risk factors for bovine tuberculosis in the state of São Paulo, Brazil. *Semina: Ciências Agrárias,* Londrina, v. 37, n. 5, p. 3673-3684, 2016. Suplemento 2.

DOHOO, I.; MARTIN, W.; STRYHN, H. *Veterinary epidemiologic research*. Charlottetown: Atlantic Veterinary College, 2003. 706 p.

GALVIS, J. O. A.; GRISI-FILHO, J. H. H.; COSTA, D.; SAID, A. L. P. R.; AMAKU, M.; DIAS, R. A.; FERREIRA, F.; GONÇALVES, V. S. P.; HEINEMANN, M. B.; TELLES, E. O.; FERREIRA NETO, J. S. Epidemiologic characterization of bovine tuberculosis in the state of Espírito Santo, Brazil. *Semina: Ciências Agrárias,* Londrina, v. 37, n. 5, p. 3567-357, 2016. Suplemento 2.

GUEDES, I. B.; BOTTENE, I. F. N.; MONTEIRO, L. A. R. C.; LEAL FILHO, J. M.; HEINEMANN, M. B.; AMAKU, M.; GRISI-FILHO, J. H. H.; DIAS, R. A.; FERREIRA, F.; TELLES, E. O.; GONÇALVES, V. S. P.; FERREIRA NETO, J. S. Prevalence and risk factors for bovine tuberculosis in the state of Mato Grosso do Sul, Brazil. *Semina: Ciências Agrárias,* Londrina, v. 37, n. 5, p. 3579-3588, 2016. Suplemento 2.

HOSMER, D. W.; LAMESHOW, S. *Applied logistic regression*. New York: John Wiley and Sons, 1989. 307 p.

HUMBLET, M. F.; GILBERT, M.; GOVAERTS, M.; FAUVILLE-DUFAUX, M.; WALRAVENS, K.; SAEGERMAN, C. New assessment of bovine tuberculosis risk factors in Belgium based on nationwide molecular epidemiology. *Journal of Clinical Microbiology*, Barcelona, v. 48, n. 8, p. 2802-2808, 2010.

LAGE, A. P.; ROXO, E.; MÜLLER, E.; POESTER, F.; CAVALLÉRO, J. C. M.; FERREIRA NETO, J. S.; MOTA, P. M. P. C.; GONÇALVES, V. S. P. *Programa nacional de controle e erradicação da brucelose e da tuberculose animal* (PNCEBT). Brasília: Ministério da Agricultura, Pecuária e Abastecimento (MAPA), 2006. 184 p. (Manual técnico).

LIMA, P. B.; NASCIMENTO, D. L.; ALMEIDA, E. C.; PONTUAL, K. A. Q.; AMAKU, M.; DIAS, R. A.; FERREIRA, F.; GONÇALVES, V. S. P.; TELLES, E. O.; GRISI-FILHO, J. H. H.; HEINEMANN, M. B.; SILVA, J. C. R.; FERREIRA NETO, J. S. Epidemiological situation of bovine tuberculosis in the state of Pernambuco, Brazil. *Semina: Ciências Agrárias,* Londrina, v. 37, n. 5, p. 3601-3610, 2016. Suplemento 2.

MARANGON, S.; MARTINI, M.; DALLA POZZA, M.; FERREIRA NETO, J. S. A case-control study on bovine tuberculosis in the Veneto region, Italy. *Preventive Veterinary Medicine*, Colorado, v. 34, n. 2, p. 87-95, 1998.

MATO GROSSO. Secretaria de Desenvolvimento Rural e Agricultura Familiar. Instituto de Defesa Agropecuária do Estado de Mato Grosso. Coordenadoria de Controle das Doenças dos Animais. Informe Mensal Sobre Tuberculose: Diagnóstico e Profilaxia da Tuberculose. Cuiabá: INDEA/MT, 2011a.

_____. Secretaria de Desenvolvimento Rural e Agricultura Familiar. Instituto de Defesa Agropecuária do Estado de Mato Grosso. Coordenadoria de Controle das Doenças dos Animais. Sistema Informatizado de Animais. Situação 2011. Cuiabá: INDEA MT, 2011b.

_____. Secretaria Estadual de Meio Ambiente. Superintendência de Biodiversidade. Coordenadoria de Ecossistemas. Mapa dos Biomas do Estado de Mato Grosso. Cuiabá: SEMA, 2009. Disponível em: <http://www.sema.mt.gov.br/index.php?option=com_content&view=article&id=170:mapa-dos-biomas-mato-grossenses &catid=38:biodiversidade&Itemid =107>. Acesso em: 25 ago. 2011.

NEGREIROS, R. L.; DIAS, R. A.; FERREIRA, F.; FERREIRA NETO, J. S.; GONÇALVES, V. S. P.; SILVA, M. C. P.; FIGUEIREDO, V. C. F.; LÔBO, J. R.; FREITAS, J.; AMAKU, M. Situação epidemiológica da brucelose bovina no Estado do Mato Grosso. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, Belo Horizonte, v. 61, p. 56-65, 2009. Suplemento 1.

OLIVEIRA, V. M.; FONSECA, A. H.; PEREIRA, M. J. S.; CARNEIRO, A. V.; JESUS, V. L. T.; ALVES, P. A. M. Análise retrospectiva dos fatores associados à distribuição da tuberculose bovina no Estado do Rio de Janeiro. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, Belo Horizonte, v. 60, n. 3, p. 574-579, 2008.

PEREZ, A. M.; WARD, M. P.; TORRES, P.; RITACCO, V. Use of spatial and monitoring data to identify clustering of bovine tuberculosis in Argentina. *Preventive Veterinary Medicine*, v. 56, n. 1, p. 63-74, 2002.

PORPHYRE, T.; STEVENSON, M. A.; MCKENZIE, J. Risk factors for bovine tuberculosis in New Zealand cattle farms and their relationship with possum control strategies. *Preventive Veterinary Medicine*, v. 86, n. 1-2, p. 93-106, 2008.

QUEIROZ, M. R.; GROFF, A. C. M.; SILVA, N. S.; GRISI-FILHO, J. H. H.; AMAKU, M.; DIAS, R. A.; TELLES, E. O.; HEINEMANN, M. B.; FERREIRA NETO, J. S.; GONÇALVES, V. S. P.; FERREIRA, F. Epidemiological status of bovine tuberculosis in the state of Rio Grande do Sul, Brazil. *Semina: Ciências Agrárias,* Londrina, v. 37, n. 5, p. 3647-3658, 2016. Suplemento 2.

RAMÍREZ-VILLAESCUSA, A. M.; MEDLEY, G. F.; MASON, S.; GREEN, L. E. Risk factors for herd breakdown with bovine tuberculosis in 148 cattle herds in the South West of England. *Preventive Veterinary Medicine*, v. 95, n. 3-4, p. 224-230, 2010.

REGASSA, A.; TASSEW, A.; AMENU, K.; MEGERSA, B.; ABUNNA, F.; MEKIBIB, B.; MACROTTY, T.; AMENI, G. A cross-sectional study on bovine tuberculosis in Hawassa town and its surroundings, Southern Ethiopia. *Tropical Animal Health and Production*, Edinburgh, v. 42, n. 5, p. 915-920, 2010.

RIBEIRO, L. A.; GONÇALVES, V. S. P.; FRANCISCO, P. F. C.; MOTA, A. L. A. A.; NASCIMENTO, G. T.; LICURGO, J. B.; FERREIRA, F.; GRISI-FILHO, J. H. H.; FERREIRA NETO, J. S.; AMAKU, M.; DIAS, R. A.; TELLES, E. O.; HEINEMANN, M. B.; BORGES, J. R. J. Epidemiological status of bovine tuberculosis in the Federal District of Brazil. *Semina: Ciências Agrárias,* Londrina, v. 37, n. 5, p. 3561-3566, 2016. Suplemento 2.

ROCHA, W. V.; JAYME, V. S.; MOTA, A. L. A. A.; BRITO, W. M. E. D.; PIRES, G. R. C.; GRISI-FILHO, J. H. H.; DIAS, R. A.; AMAKU, M.; TELLES, E. O.; HEINEMANN, M. B.; FERREIRA, F.; FERREIRA NETO, J. S.; GONÇALVES, V. S. P. Prevalence and herd-level risk factors of bovine tuberculosis in the State of Goiás, Brazil. *Semina: Ciências Agrárias,* Londrina, v. 37, n. 5, p. 3625-3628, 2016. Suplemento 2.

SALAZAR, F. H. P. *Ocorrência de tuberculose causada por Mycobacterium bovis em bovinos abatidos em frigoríficos no Estado de Mato Grosso, Brasil.* 2005. Dissertação (Mestrado em Ciência Animal) - Faculdade de Medicina Veterinária e Zootecnia, Universidade Federal de Mato Grosso do Sul, Campo Grande.

SILVA, M. C. P.; GONÇALVES, V. S. P.; MOTA, A. L. A. A.; KOLODA, M.; FERREIRA NETO, J. S.; GRISI-FILHO, J. H. H.; DIAS, R. A.; AMAKU, M.; TELLES, E. O.; FERREIRA, F.; HEINEMANN, M. B.; ALFIERI, A. A.; MULLER, E. E. Prevalence and herd-level risk factors for bovine tuberculosis in the state of Paraná, Brazil. *Semina: Ciências Agrárias,* Londrina, v. 37, n. 5, p. 3611-3624, 2016. Suplemento 2.

SCKUCE, R. A.; ALLEN, A. R.; MCDOWELL, S. W. J. Herd-level risk factors for bovine tuberculosis: a literature review. *Veterinary Medicine International*, v. 2012, Article ID 621210, p. 1-10, 2012. Available at: <http://www.hindawi.com/journals/vmi/2012/621210/abs/>. Accessed at: 20 jun. 2015.

THRUSFIELD, M. *Veterinary epidemiology*. 3th ed. Cambridge: Blackwell Science, 2007. 610 p.

VELOSO, F. P.; BAUMGARTEN, K. D.; MOTA, A. L. A. A.; FERREIRA, F.; FERREIRA NETO, J. S.; GRISI-FILHO, J. H. H.; DIAS, R. A.; AMAKU, M.; TELLES, E. O.; HEINEMANN, M. B.; GONÇALVES, V. S. P. Prevalence and herd-level risk factors of bovine tuberculosis in the State of Santa Catarina, Brazil. *Semina: Ciências Agrárias,* Londrina, v. 37, n. 5, p. 3659-3672, 2016. Suplemento 2.

VENDRAME, F. B.; AMAKU, M.; FERREIRA, F.; TELLES, E. O.; GRISI-FILHO, J. H. H.; GONÇALVES, V. S. P.; HEINEMANN, M. B.; FERREIRA NETO, J. S.; DIAS, R. A. Epidemiologic characterization of bovine tuberculosis in the State of Rondônia, Brazil. *Semina: Ciências Agrárias,* Londrina, v. 37, n. 5, p. 3639-3646, 2016. Suplemento 2.

ZENDEJAS MARTÍNEZ, H.; MILIAN SUAZO, F.; CUADOR GIL, J. Q.; CRUZ BELLO, G.; ANAYA ESCALERA, A. M.; HUITRÓN MÁRQUEZ G.; GARCÍA CASANOVA. L. Spatial epidemiology of bovine tuberculosis in Mexico. *Veterinaria Italiana*, v. 43, n. 3, p. 629-634, 2007.

ZENDEJAS-MARTÍNEZ, H.; TOWNSEND, A. P.; MILIÁN-SUAZO, F. Coarse-scale spatial and ecological analysis of tuberculosis in cattle: An investigation in Jalisco, Mexico. *Geospatial Health*, v. 3, n. 1, p. 29-38, 2008.