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Prevalence and herd-level risk factors of bovine tuberculosis in the State of Goiás, Brazil

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Prevalência e Fatores de Risco da Tuberculose Bovina no Estado de Goiás, Brasil

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Abstract

Bovine tuberculosis results in economic losses in livestock production and poses a risk to public health. This study aimed to characterize the epidemiological status of bovine tuberculosis in adult cows in the state of Goiás, Brazil. The state was divided into three sampling strata, corresponding to different livestock production circuits. A total of 18,659 animals were tested with the comparative cervical tuberculin test (CCT), in 300 randomly sampled bovine herds per stratum. An epidemiological questionnaire was used to identify health and management practices that may be associated with the presence of tuberculosis infection in the herd. In Stratum 1, dominated by beef cattle, no animals reacted to the CCT. In Stratum 2, which covers the main dairy regions of the state, the prevalence was estimated at 8.67% [5.73 to 12.74%] for herds and at 0.9% [0.21 to 1.58%] for animals. In Stratum 3, characterized by a mix of dairy, beef and dual-purpose herds, the prevalence was estimated at 1.00% [0.21 to 2.89] for herds and 0.30% [0.10 to 0.49 %] for animals. The overall prevalence in the state of Goiás was 3.43% [2.20 to 4.67%] for herds and 0.30% [0.10 to 0.49%] for animals. The multiple logistic regression analysis revealed that herd-level risk factors associated with the presence of the bovine tuberculosis are: the location of the herd in Stratum 2 (OR = 12.05 [3.52 to 41.28]) and the number of times a cow is milked per day (OR = 6.27 [2.72 to 14.44]). Regular veterinary care was identified as a protective factor (OR = 0.38 [0.15-0.94]). These results indicate that bovine tuberculosis is endemic in the state; its spatial distribution is heterogeneous with a strong concentration in dairy regions. The most intensive dairy farms are those with the highest risk, which is consistent with what other authors' found elsewhere in Brazil. The epidemiological information generated by this study provides information for planning of risk-based surveillance actions, and justifies the adoption of free-herd certification programs for bovine tuberculosis in the main dairy regions of Goiás.
Key words: Cattle. *Mycobacterium bovis*. Prevalence. Risk factors. Goiás.

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Resumo

Em virtude da tuberculose bovina produzir prejuízos econômicos na pecuária e ter impacto na saúde pública, realizou-se, no Estado de Goiás, um estudo para caracterizar a situação epidemiológica da enfermidade em fêmeas bovinas adultas. O Estado foi estratificado em três circuitos produtores. Em cada circuito foram amostradas aleatoriamente 300 propriedades, onde foi sorteado um número pré-estabelecido de animais que foram submetidos à tuberculinização cervical comparada, totalizando 18.659 animais. Foi aplicado, em cada propriedade, questionário epidemiológico para verificar as práticas sanitárias e de manejo que poderiam estar associadas ao risco de infecção pela doença. No estrato 1, onde predominam propriedades de bovinocultura de corte, não foi detectado nenhum animal reagente ao teste. No estrato 2, que abrange as principais regiões leiteiras do Estado, a prevalência foi de 8,67% [5,73-12,74%] para propriedades e de 0,9% [0,21-1,58%] para animais. No estrato 3, onde existe um equilíbrio entre a produção de leite e corte, estimou-se a prevalência em 1,00% [0,21-2,89] para propriedades e 0,30% [0,10-0,49%] para animais. A prevalência global no Estado de Goiás foi de 3,43% [2,20-4,67%] para propriedades e de 0,30% [0,10-0,49%] para animais. Os fatores de risco associados à condição de foco, na regressão logística múltipla foram: localização da propriedade no estrato 2 (OR = 12,05 [3,52-41,28]), realização de duas ou três ordenhas diárias (OR = 6,27 [2,72-14,44]). A assistência veterinária se apresentou como fator de proteção (OR = 0,38 [0,15-0,94]). Estes resultados permitem concluir que a tuberculose bovina é endêmica no Estado e sua distribuição espacial é heterogênea, com forte concentração nas regiões leiteiras. As propriedades leiteiras mais tecnificadas são as que apresentam risco mais elevado, à semelhança do que outros autores encontraram em diversos estados brasileiros. A informação epidemiológica gerada por este estudo permite adequar as ações de vigilância aos fatores de risco identificados e justifica a adoção de programas de certificação de propriedades livres de tuberculose bovina nas principais bacias leiteiras de Goiás.

Palavras-chave: Bovinos. *Mycobacterium bovis*. Prevalência. Fatores de risco. Goiás.

Introduction

Bovine tuberculosis is a zoonosis found throughout the world. It is caused by *Mycobacterium bovis* (*M. bovis*) and is one of the endemic diseases that generate major challenges to government authorities, medical and veterinary professionals, as well as agribusiness value-chains (SKUCE et al., 2012; OIE, 2015). Bovine tuberculosis poses a threat to public health, especially through human consumption of milk and dairy products, as well as by exposure to the aerosols of infected animals (BILAL et al., 2010).

Although the etiological agent of bovine tuberculosis agent has been identified for more than a century, advances in knowledge and technology available for its control have not been sufficient to eradicate the disease worldwide, especially in developing countries (DE KANTOR; RITACCO, 2006; VORDERMEIER et al., 2012). This disease is of global importance and requires mandatory notification (OIE, 2016), which poses a considerable obstacle to the international trade of animals, as well as their products and by-products (AMANFU, 2006).

Due to the economic and social impacts resulting from the occurrence of bovine tuberculosis and brucellosis, the Ministry of Agriculture, Livestock and Food Supply (MAPA) has established, through Normative Instruction (IN) Nº 02/2001, the National Program for Control and Eradication of Animal Brucellosis and Tuberculosis (PNCEBT) (BRASIL, 2001). In 2004, the rules were revised by IN SDA Nº. 06.

One of the initial goals of PNCEBT is the epidemiological characterization of tuberculosis and brucellosis in the Brazilian states. Bovine tuberculosis studies were conducted in 12 Federative Units, which accounted for 65% of the Brazilian cattle population (BAHIENSE et al., 2016; BARBIERI et al., 2016; DIAS et al., 2016; GALVIS et al., 2016; GUEDES et al., 2016; LIMA et al., 2016; NÉSPOLI et al., 2016; QUEIROZ et

al., 2016; RIBEIRO et al., 2016; SILVA et al., 2016; VELOSO et al., 2016; VENDRAME et al., 2016).

The state of Goiás is located in the Midwest region of Brazil, covering a geographical area of 340.111 km² (BRASIL, 2016a). It has the third largest cattle herd in the country, with 21.8 million cattle (BRASIL, 2016b), distributed throughout 126,000 farms (GOIÁS, 2016a). It is the third largest milk production state in the country, with 3.8 billion liters/ year (BRASIL, 2016c). Agribusiness accounts for 77% of the state's exports, which, in 2015, amounted to a total of 5.9 billion dollars (GOIÁS, 2016b). Considering that agribusiness is vital to the economy of Goiás, the state must prioritize the health of its cattle in order to conquer and consolidate markets.

No data on the prevalence of bovine tuberculosis in Goiás was found in scientific literature. The disease related data available was communicated by accredited veterinarians who conduct field testing, corresponding to a frequency of test-positive animals of 0.12% in 2010, 0.18% in 2011, 0.13% in 2012, 0.23% in 2013 and 0.24% in 2014 (PIRES, 2016). This study aimed to estimate the prevalence and regional distribution of tuberculosis in adult cows in the state of Goiás, as well as herd-level risk factors in order to provide subsidies for efficient management of the control/ eradication program.

Materials and Methods

This study was part of a project involving MAPA and the Agency of Goiás for Animal and Plant Health (AGRODEFESA), in collaboration with the Laboratory of Epidemiology and Biostatistics at the University of São Paulo (LEB / VPS / FMVZ / USP), the Laboratory of Epidemiology at the University of Brasília (EpiPlan / FAV / UnB), and the Sector of Preventive Veterinary Medicine of the Federal University of Goiás (MVP / EVZ / UFG). The study was a cross-sectional random survey that comprised 900 farms, encompassing the entire territory of Goiás. Field activities were performed from August of 2013 to December of 2014.

To describe regional differences in prevalence a division in sampling strata was used, following the criteria described by Rocha et al. (2009). Three regions were established according to the cattle production trends in each region. In Stratum 1 (North and Northeast), beef cattle and extensive farming are predominant; Stratum 2 (South and Southeast) includes the main milk production region in Goiás, while Stratum 3 (Southeast and Central) is more heterogeneous, consisting of dairy herds, beef cattle, or dual purpose herds (mixed). The boundaries of the three regions are shown in Figure 1.

Sample design

To calculate the sample size of the primary units (herds), a prevalence of 5% for cattle was assumed, as well as a 95% confidence level, an acceptable maximum error of 2.5%, and a total population of 125,839 farms with cows according to the AGRODEFESA register. A total of 300 herds was randomly selected using the Epi Tools® software. Since each stratum is a distinct epidemiological region, the hypothesis presented was tested separately for each of the three strata, resulting in a total sample size of 900 herds. Within each stratum herds were selected using systematic random sampling.

The sample design for the secondary units (animals) aimed at estimating a minimum number of animals for testing within each herd, in order to classify its status for bovine tuberculosis. The sample size calculations aimed at achieving a predefined value of herd-level sensitivity and specificity, as recommended by Dohoo et al. (2003). We used values of 77.5% and 99.5% respectively for the sensitivity and specificity of the cervical comparative tuberculin test (CCT), as reported by Lobo (2008). Within-herd prevalence was assumed to be 15%, which was the best guesstimate reported in a study conducted in Minas Gerais (BELCHIOR et al., 2016). After simulating different herd and

sample sizes using the Epi Tools® software, it was decided that in herds with fewer than 20 adult cows all animals should be tested. For herds including between 20 and 99 adult cows, 20 were randomly tested. In both situations, one single test-positive animal would classify the herd as positive. In herds with 100 or more adult cows, 40 were randomly sampled and the cut-off point of test-positive animals was two, in order to classify the herd as positive. Cows that had calved within the last 15 days were not tested. In farms that held more than one cattle herd, the one with greater economic impact was selected.

The distribution of existing and sampled herds and animals in the selected strata is shown in Table 1.

Figure 1. Goiás geographical division, outlining the sampling strata that composed the epidemiological study of bovine tuberculosis.
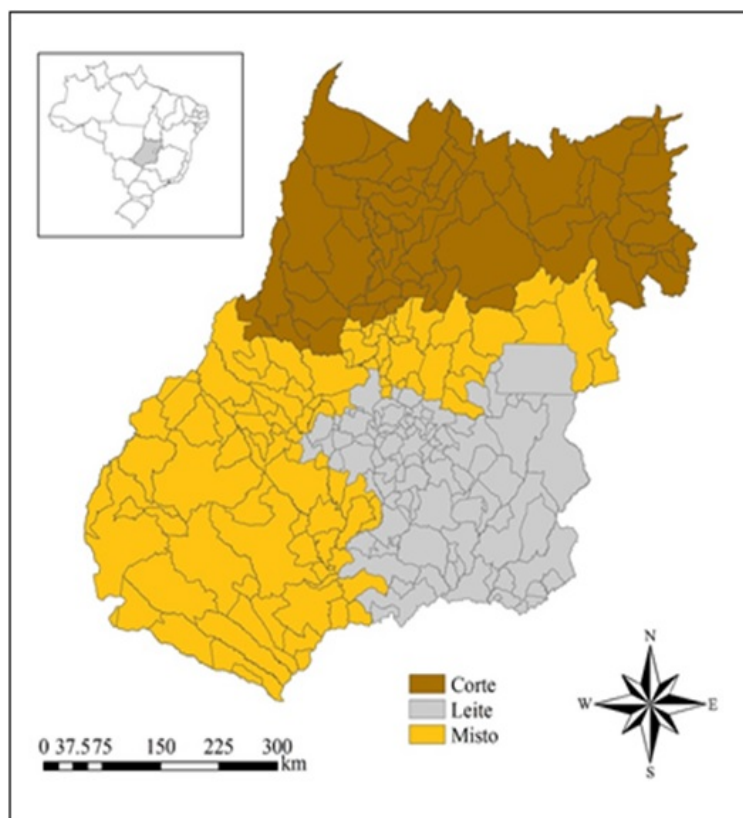
Source: Rocha et al. (2009).

Table 1. Census and sample data of herds and adult cows, stratified by sampling stratum in the state of Goiás, in 2014.

Stratum	Herds with breeding females	Sampled herds	Total number of cows $\geq$ 24 months	Cows sampled
1 – North and Northeast	36,007	300	2,614,454	6,510
2 – South and Southeast	44,629	300	2,486,797	6,423
3 – Southwest and Central	45,203	300	3,933,895	5,726
Total	125,839	900	9,035,146	18,659

Source: GOIÁS (2014). Unpublished data, referring to FMD vaccination in May of 2014.

Field work

At least three visits to each farm included in the study were scheduled. On the first visit, the producer was informed of the procedures and if he/she agreed to participate, a term of commitment was signed which established an agreement to aid in activities and to keep the animals in one location until the results were obtained. On the second visit, the epidemiological questionnaire and tuberculin testing of animals were conducted; the third visit aimed at reading the CCT results. In the presence of positive animals, a fourth visit was scheduled for sanitary slaughter or euthanasia of animals on the premises. In such cases, the producer was compensated by the Fund for the Development of Agriculture of the State of Goiás (FUNDEPEC-GOIÁS), at a value of R$ 700.00 per animal.

The animals selected underwent a CCT test. The preparation procedures, inoculations, and readings adhere to the provisions of the PNCEBT technical manual (BRASIL, 2006). If the outcome was inconclusive, the animal required retesting after a minimum interval of 60 days. A second inconclusive result was considered positive. The tests were conducted by 60 trained veterinarians from AGRODEFESA, ensuring the necessary standardization of testing.

Epidemiological questionnaire

The questionnaire included 26 closed-answer questions and 6 open-answer questions in order to capture data about each farm. It was structured in blocks in order to facilitate the organization of profile information – the zootechnical profile of the heard, health and reproductive management, as well as usual practices of the residents that may be related to the disease risk or pose a public health hazard. Data were stored in an online database, provided by the Laboratory of Epidemiology and Biostatistics at the University of São Paulo (LEB / VPS / FMVZ / USP).

The questionnaire variables were: the type of operation or production system – beef, dairy or dual-purpose; type of management – confined, semi-confined or extensive; number of milkings per day; and type of milking – manual or mechanical. Additional variables included the use of artificial insemination; the presence of other domestic species and/or wild animals; the purchase, sale, and sanitary control of animals; the disposal methods for culled stock; pasture rental; shared or flooded pastures; and the use of regular veterinary services.

Statistical analysis

The sample design aimed to estimate the prevalence of herds and animals with bovine tuberculosis in the state of Goiás, in each of the three sampling strata. Considering that the number of herds in each sampling stratum differed, and the number of animals in a herd was not the same for all farms, it was necessary to weigh the prevalence at both levels so that the obtained sample results can be inferred for the target population. The weights of each herd (P1) and each animal (P2) were derived as follows:

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$$P_1 = \frac{\textit{Existing herds in the stratum}}{\textit{Sampled herds in the stratum}}$$

$$P_2 = \frac{\textit{Cows} \geq \textit{24m in the herd}}{\textit{Cows} \geq \textit{24m sampled in the herd}} \times$$

$$\frac{\textit{Cows} \geq \textit{24m in the stratum}}{\textit{Cows} \geq \textit{24m sampled in the stratum}}$$

Prevalence estimates were obtained using STATA® MP 12 software.

As an initial step to identify possible risk factors, a univariate analysis of biological and epidemiological factors and questionnaire variables associated with the presence or absence of tuberculosis was performed. The analysis used the χ^2 test. The variables with a p-value ≤ 0.20 were included in multiple logistic regression analysis. When necessary, variables were regrouped, and the lowest risk category was taken as the baseline.

The "hierarchical backward elimination" technique (KLEINBAUM; KLEIN, 2010) was employed in the logistic regression modelling

in order to obtain a reduced model. We used two methodologies: model-based and design-based logistic regression. The design-based formats in each stratum considered sample weights, as recommended by Hosmer et al. (2013), respecting the sampling design. This is appropriate for population inference of risk factors.

To evaluate the adjustment of the model-based format, the likelihood ratio test was performed. To assess the discriminatory performance of variables in the final logistic model, we used the ROC curve (Receiver Operating Characteristic) to verify the predictive power of the model. Results were obtained using the graph function of STATA® MP 12 software.

Results

Figure 2 shows the location of sampled herds, as well as of test-positive herds, throughout the state of Goiás. Of the 900 randomly selected properties, 21 were classified as positive for bovine tuberculosis and are represented as black dots in Figure 2. The georeferenced map was constructed using the ArcGIS® 10.3 software.

Figure 2. Spatial distribution of herds sampled and herds positive for bovine tuberculosis in Goiás, 2014.
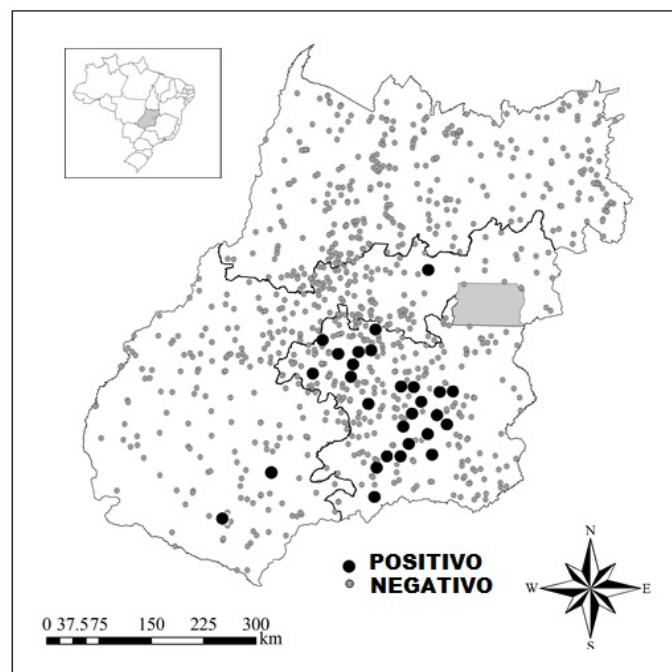
The herd-level prevalence of bovine tuberculosis in the state of Goiás and in each sampling strata is displayed in Table 2. Herd prevalence was higher in the dairy region (stratum 2) compared to the dual-purpose region (stratum 3), whereas no positive herds were found in the beef region (stratum 1). Of the 900 herds in the sample, 650 had up to 99 adult cows and 250 had over 100. According to the criteria for classifying a positive herd, six herds with more than 99 adult cows were classified as negative, despite containing one single test-positive cow (i.e. below the cut-off point). Of these, five were located in Stratum 2 and one in Stratum 3, which is consistent with the regional trend observed for positive herds.

Table 2. Herd prevalence of bovine tuberculosis, stratified by region, in the state of Goiás, 2014.

Stratum (region)	Herds		Apparent Prevalence (%)	95% Confidence Interval
	Tested	Positive		
1 – North and Northeast	300	0	0.00	[0.00 – 1.22]
2 – South and Southeast	300	26	8.67	[5.73 – 12.74]
3 – Southwest and Central	300	3	1.00	[0.21 – 2.89]
Goiás	900	29	3.43	[2.20 – 4.67]

A total of 18,659 adult cows were tested, resulting in 48 positive and 91 inconclusive results. Cattle with inconclusive results were retested after 60 days, of which 23 were positive, resulting in a total of 71 positive females. Table 3 displays the number of sampled adult cows, the tuberculosis prevalence in different strata and their respective confidence intervals. The prevalence of bovine tuberculosis was low in Goiás but the geographical distribution of positive herds and animals was highly heterogeneous, with the dairy region (Stratum 2) presenting a much higher prevalence than the rest of the state.

Table 3. Prevalence of bovine tuberculosis in adult females, stratified by region, in the state of Goiás, 2014.

Stratum (region)	Cows ≥ 24 months		Apparent Prevalence (%)	95% Confidence Interval
	Tested	Positive		
1 – North and Northeast	6,477	0	0.00	-
2 – South and Southeast	6,422	63	0.90	[0.21 – 1.58]
3 – Southwest and Central	5,760	8	0.11	[0.00 – 0.22]
Goiás	18,659	71	0.30	[0.10 – 0.49]

Univariable Analysis

Table 4 displays the questionnaire variables for which the p-value of the χ^2 test was lower than 0.2 in the univariable analysis.

Table 4. Questionnaire variables for which the p-value of the χ^2 test was lower than 0.2 in the univariable analysis.

Herd-level variable	Exposed/ positive	Exposed/ negative	p-value
Stratum/region			<0.001
2 – South and Southeast	26/29	274/871	
(1 + 3) – (North and Northeast + Southwest and Central)	3/29	597/871	
Type of cattle operation			<0.001
Dual-purpose	10/29	339/871	
Dairy	18/29	225/871	
Beef	1/29	307/871	
Type of feeding system			<0.001
Confined + semi-confined	14/29	130/871	
Extensive grazing only	15/29	741/871	
Bovine species			<0.001
European dairy	15/29	128/871	
Crossbreed	13/29	374/871	
(Zebu + European dairy + other species)	1/29	369/871	
Number of milkings per day			<0.001
None or only 1 milking	10/29	719/871	
2 or 3 milkings	19/29	152/871	
Type of milking			<0.001
No milking + manual milking	15/29	735/871	
Milking parlour	10/29	80/871	
Mechanical milking with portable device	4/29	56/871	
Use of artificial insemination			0.084
None	23/29	762/871	
Uses artificial insemination and bull	3/29	83/871	
Uses artificial insemination only	3/29	26/871	
Backyard pig production			0.102
Yes	21/29	498/871	
No	8/29	373/871	
Capybaras on the farm			0.071
Yes	14/29	281/871	
No	15/29	590/871	
Purchased cattle are tuberculin tested			0.023
Yes	5/20	47/497	
No	15/20	450/497	
Cattle are slaughtered at the end of the reproductive life			0.036
Yes	13/29	557/871	
No	16/29	314/871	
Rents pastures			0.123
Yes	5/29	265/866	
No	24/29	601/866	
Shares pastures with other farms			0.185
Yes	1/29	98/869	
No	28/29	771/869	
Has marshy areas to which livestock have access			0.069
Yes	4/29	255/869	
No	25/29	614/869	

continuation

Delivers milk produced on the farms			<0.001
Yes	25/29	452/871	
No	4/29	419/871	
Refrigerates the milk produced on farm			0.032
Yes	21/29	306/871	
No	8/29	565/871	
Produces cheese or butter on farm			0.065
Yes	17/29	361/871	
No	12/29	510/871	
Veterinary care			0.184
Present	7/29	315/871	
Absent	22/29	556/871	
Feeds cattle with bovine serum milk			0.012
Yes	2/29	11/871	
No	27/29	860/871	
Shares watery areas with other farms			0.036
No	27/29	665/870	
Yes	2/29	205/870	
Number of cows over 24 months (categorized)			0.093
Up to 15	3/29	207/871	
Between 16 and 40	7/29	249/871	
Between 41 and 150	16/29	293/871	
Above 150	3/29	122/871	

Multiple logistic regression analyses

The final logistic regression models only included variables with p values < 0.05. Tables 5 and 6 display the model-based and design-based models, respectively, indicating the variables, the Odds Ratios and the corresponding 95% confidence intervals.

Table 5. Results of the multiple logistic regression in the model-based format.

Variable	*Odds Ratio*	CI (95%)	p
Stratum/Region			
Regions 1 and 3	Baseline		
Region 2 (South and Southeast)	12.05	[3.52 – 41.28]	<0.001
Number of milkings per day			
None or once a day	Baseline		
2 or 3 daily milkings	6.27	[2.72 – 14.44]	<0.001
Regular veterinary care			
No	Baseline		
Yes	0.38	[0.15 – 0.94]	0.04

Table 6. Results of the multiple logistic regression in the design-based format.

Variable	Odds Ratio	CI (95%)	p
Number of milkings per day			
None or once a day	baseline		
2 or 3 daily milkings	11.20	[5.01 – 25.04]	<0.001
Regular veterinary care			
No	baseline		
Yes	0.31	[0.13 – 0.76]	0.01

The likelihood ratio test in the model-based format was statistically significant (p = 0.002); the discriminatory performance of variables calculated by the ROC curve were valued at 0.8730, indicating a good discrimination value between positive and negative flocks. According to parameters set by Kleinbaum and Klein (2010), a value between 0.8 and 0.9 for the Area Under the Curve indicates good predictive ability of the model. The curve is shown in Figure 3.

Figure 3. ROC curve of the multiple logistic regression model in the model-based format.

Área abaixo da curva ROC = 0.8730
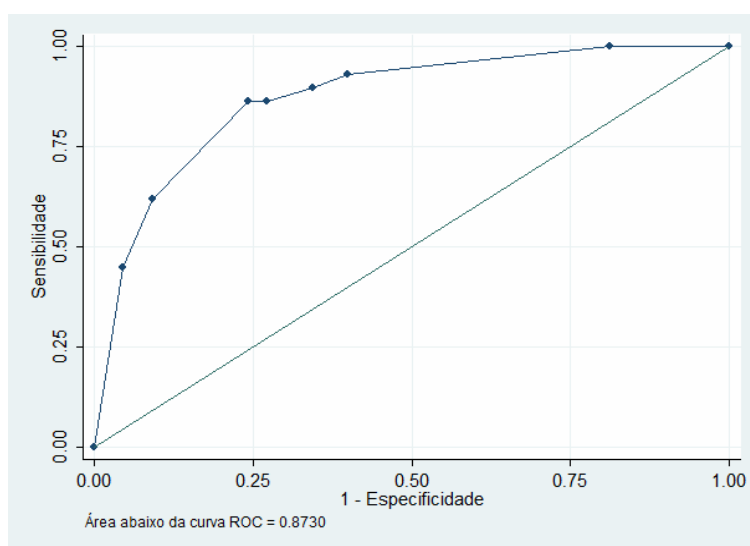
The results of the design-based logistic model are more appropriate for making inferences of risk factors to the overall cattle population of the state of Goiás. The variables that remained in this model were the same described for the model-based logistic regression, as displayed in Table 6, except for the stratum/region, as this variable was used for weighting the sample and, therefore, cannot be included in the design-based format.

Both models showed a strong association between the number of milkings and the presence of bovine tuberculosis in the herd. The effect was stronger in the design-based model, probably due to the absence of the variable "stratum". Since the sample weights were very similar across the three regions, the unweighted model (model-based) may serve as a good indicator of risk factors at the state level, despite the absence of a stratified sampling design. Thus, the probability that a cattle herd was positive in Goiás increased with location in the South or Southeast (Stratum 2) and with the intensification of production, measured by the number of milkings

per day. In addition, herds that received regular veterinary care had lower risk of being positive, which makes a case for the importance of veterinary services as a preventive measure.

There was a correlation between the presence of bovine tuberculosis with factors related to the handling of milk and dairy products, and the consumption habits on farm. The results revealed that tuberculosis occurred in 5.1% of the farms in which drinking raw milk was reported as a habit and in 4.7% of the farms that produced cheeses and butter for consumption and/ or sale. These indices are twice as high as those observed in farms that did not engage in such practices. Almost all cheese and butter produced on farm uses fresh milk as a raw material (BELCHIOR et al., 2016), clearly showing the risk for consumers and the need for preventing bovine tuberculosis.

Discussion

The weighted herd prevalence of bovine tuberculosis in cattle in the state of Goiás was 3.43% [2.20% – 4.57%]. This is below values estimated for the states Espírito Santo and São Paulo; similar to what has been reported for Bahia, Pernambuco, Rondonia, Mato Grosso do Sul, Mato Grosso, Rio Grande do Sul and Minas Gerais, but above what has been estimated for Santa Catarina (BAHIENSE et al., 2016; BARBIERI et al., 2016; DIAS et al., 2016; GALVIS et al., 2016; GUEDES et al., 2016; LIMA et al., 2016; NÉSPOLI et al., 2016; QUEIROZ et al., 2016; RIBEIRO et al., 2016; SILVA et al., 2016; VELOSO et al., 2016; VENDRAME et al., 2016).

In this study, bovine tuberculosis was strongly concentrated in the dairy region (Stratum 2) located the South/Southeast regions of Goiás, where the prevalence of herds was 8.67% [5.73 to 12.74]. This finding was comparable to that found in the most important dairy basins of the neighboring state of Minas Gerais (BELCHIOR et al., 2016), where herd prevalence in the regions of Alto Paranaiba and South/Southwest was 9.66% [5.73 to 15.01]

and 7.17% [4.31 to 11.10], respectively. These regions are home to important dairy operations and are contiguous to the South and Southeast regions of Goiás. The North and Northeast regions of the Goiás showed a low prevalence of bovine tuberculosis, with rates similar to those presented in neighboring regions, as reported by Costa (2012) in western Bahia, and by Néspoli et al. (2016) in the eastern region of the state of Mato Grosso. Such regions are characterized by extensive animal production, a factor that minimizes the spread of bovine tuberculosis.

The results of this study indicate that risk factors of bovine tuberculosis increased in dairy herds, notably those with more intensive production, which may be related to breeding systems in partial or total confinement. This shows similarities to the findings of previous studies on bovine tuberculosis risk factors reported in Paraná (SILVA et al., 2016), Bahia (BAHIENSE et al., 2016), Rondônia (VENDRAME et al., 2016), Mato Grosso (NÉSPOLI et al., 2016), Santa Catarina (VELOSO et al., 2016), and Minas Gerais (BELCHIOR et al., 2016).

By using the same analytical methodology, previous studies have concluded that the risk of bovine TB is higher for more technologically advanced dairy operations. In order to increase the quality and value of dairy products, risk-based surveillance should be targeted at this sector, which would benefit from integration into herd accreditation programs, as established by the PNCEBT. The reduction of risks to human health makes it necessary to intensify sanitary education and disease prevention in farms where dairy products are produced, usually with unpasteurized milk.

This study demonstrated that regular veterinary care reduced the risk of bovine tuberculosis, highlighting the significant role of accredited veterinarians in the PNCEBT for the provision of regular testing, as well as sanitary education.

Conclusions

Tuberculosis is endemic in the state of Goiás; its spatial distribution is heterogeneous, with a strong concentration in dairy regions of the south and southeast. Overall, the prevalence of bovine tuberculosis is low, which makes it possible to implement a disease eradication plan, following recommendations of the PNCEBT.

The results of this study are consistent with estimates obtained in previous surveys conducted in various units of the Federation, which concluded that more intensive dairy farms present a greater risk of bovine tuberculosis.

The epidemiological information generated by this study justifies the adoption of risk-based surveillance activities targeted at high-yield dairy farms, and strengthens the case for the adoption of strategies for accreditation of free herds in dairy basins of Goiás.

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