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Prevalence and geospatial distribution of bovine cysticercosis in the state of Mato Grosso, Brazil

Gabriel Augusto Marques Rossi[a,*], Heloisa Adélia Stefanoni de Simoni[b], Welber Daniel Zanetti Lopes[c], Henrique Meiroz de Souza Almeida[a], Vando Edésio Soares[d], Ana Maria Centola Vidal[e], Antonio Sergio Ferraudo[a], Luis Antonio Mathias[a]

[a] UNESP—Univ. Estadual Paulista, Faculdade de Ciências Agrárias e Veterinárias (FCAV), Via de acesso Paulo Castellane, s/n, CEP 14884-900, Jaboticabal, São Paulo, Brazil
[b] Esp. Instituto Qualittas de Pós-Graduação (Student) and Brazil's Federal Inspection Service (SIF), Av. Ulisses Guimarães, 889, Polo Industrial III, CEP 78500-000, Colider, Mato Grosso, Brazil
[c] Instituto de Patologia Tropical e Saúde Pública, Universidade Federal de Goiás, 74605-050 Goiânia, Goiás, Brazil,
[d] Universidade Camilo Castelo Branco (Unicastelo), Av. Hilário da Silva Passo 950, 13690-970, Descalvado, São Paulo, Brazil,
[e] Universidade de São Paulo, Faculdade de Zootecnia e Engenharia de Alimentos (FZEA), Avenida Duque de Caxias Norte 225, CEP 13635-900, Pirassununga, São Paulo, Brazil,

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ABSTRACT

This study focused on estimating the prevalence and evaluating the geospatial distribution of bovine cysticercosis in the state of Mato Grosso, Brazil. To this, we used data of 6,200,497 animals slaughtered during the years of 2013 and 2014, and from 141 municipalities of the state. The prevalence observed for this period was 0.0873% (95% CI 0.0851–0.0897). Regarding the cysticerci detected, the calcified ones were the most frequent (74.43%). The high *odds ratios* were observed in animals reared in the Administrative Regions of Sinop, Barra do Garças, Água Boa, Cáceres, Barra do Bugres, Cuiabá, Pontes Lacerda, Rondonópolis, Matupa, São Félix do Araguaia and Lucas do Rio Verde, respectively. Furthermore, the results indicate the existence of a relation between the areas with high cysticercosis prevalence and human population density. We highlight the need of the development of a risk model based on the origin to improve cysticercosis detection in endemic areas.

1. Introduction

The taeniosis-cysticercosis complex caused by *Taenia saginata* is a tropical disease that causes economical losses to the beef supply chain and has a great public health importance in developing countries such as Brazil (Rossi et al., 2015). It is estimated that, annually, approximately US$164 million are lost in Latin America due to bovine cysticercosis (Schantz et al., 1994).

Moreover, meat infected with cysticerci is the main infection source of taeniosis to humans who are the definitive hosts (Ferreira et al., 2014). Consequently, a visual inspection of beef carcasses during slaughter is required to reduce the risk for consumers (Hill et al., 2014). However, the ongoing visual inspection model fails in identifying carcasses with low infection if only the parasite's preferential sites are analyzed (Lopes et al., 2011).

Risks factors associated with cysticercosis are often described in literature, such as: the access of cattle to non controlled water sources (Kyvsgaard et al., 1991); the presence of fishermen in the surroundings of the farm (Rossi et al., 2015); the use of urban sewage sludge on pastures (Cabaret et al., 2002); the presence of roads or car parking lots adjacent to pastures as well as recreational sites (Flütsch et al., 2008); contaminated food (Jenkins et al., 2013) and organic farming (Calvo-Artavia et al., 2013a,b). Still, further studies are required for a better understanding of the global epidemiology of the complex (Laranjo-González et al., 2016).

* Corresponding author at: Via de acesso Prof. Paulo Donato Castellane s/n, Jaboticabal, CEP 14884-900, São Paulo, Brazil.
E-mail addresses: gabrielrossiveterinario@hotmail.com, gabrielrossiveterinario@gmail.com (G.A.M. Rossi), heloisa_stefanoni@hotmail.com (H.A.S. de Simoni), wdzlopes@hotmail.com (W.D.Z. Lopes), henri_almeida2003@yahoo.com.br (H.M.d.S. Almeida), soaresvando@gmail.com (V.E. Soares), anavidal@usp.br (A.M.C. Vidal), ferraudo@fcav.unesp.br (A.S. Ferraudo), lmathias@fcav.unesp.br (L.A. Mathias).

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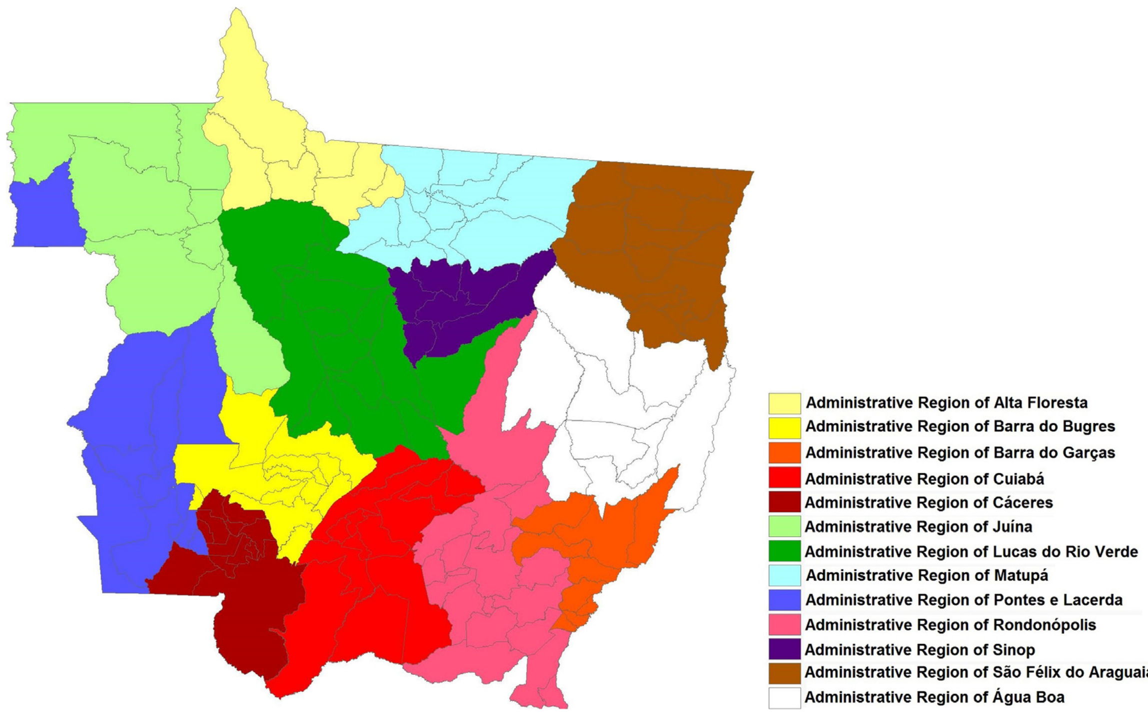

Fig. 1. Geospatial distribution of the Administrative Regions which had cattle slaughtered in the state of Mato Grosso, Brazil, during the years of 2013 and 2014.

In Brazil, the prevalence of the disease variates in the different regions and states, and the epidemiology needs to be better understood (Dutra et al., 2012), mainly in the state of Mato Grosso, which has the country's largest cattle population (Brazil, 2014). Considering this, the purpose of this study was estimating the prevalence and evaluating the geospatial distribution of bovine cysticercosis in the state of Mato Grosso, Brazil.

2. Material and methods

Data regarding the occurrence of cysticerci in 6,200,497 bovine carcasses of both sexes, with age ranging from 18 to 60 months, originated from all the 141 municipalities in the state of Mato Grosso, Brazil and slaughtered throughout the years 2013 and 2014, was obtained. All information was gathered from reports of carcasses rejection occurrence, of the Brazilian Federal Inspection Service (SIF). Such reports listed the municipality, the total number of slaughtered animals and the number of animals infected with viable and/or calcified cysticerci.

However, besides analyzing the data by each municipality, we also analyzed the data by administrative region. The studied area is divided into 13 administrative regions: Água Boa, Alta Floresta, Barra do Bugres, Barra do Garças, Cáceres, Cuiabá, Juína, Lucas do Rio Verde, Matupá, Pontes e Lacerda, Rondonópolis, São Félix do Araguaia and Sinop (Fig. 1).

The animals' slaughter was according to the standard production technology for bovines adopted in Brazil. SIF inspection agents properly trained to perform *post mortem* inspection performed the inspection of carcasses and viscera. The routine examination for the detection of cysticerci occurred in the inspection lines (head, tongue, heart, diaphragm and esophagus) (Brazil, 1952). If cysticerci were detected in the carcass, the lesions were identified and the half carcass, altogether with the viscera and the head were sent to the Final Inspection Department (DIF), where it was examinated by a veterinarian agent. Afterwards, the cysticerci found were classified into viable or calcified (Costa et al., 2012).

The statistical analysis was performed using the software Epi-info 3.5.1. The prevalence and the 95% confidence interval (95% CI) were calculated through the Wilson's Method (Thrusfield, 2010). The relation among animal's cysticercosis and the Administrative Regions was calculated using that one with lower prevalence, which were considered as OR = 1 and the others were compared with it (Thrusfield, 2010).

Statistical data of the state of Mato Grosso total area of corn production (hectares), soy (hectares), total bovine herd (number of animals), total human population, population density (pop. per km^2), human development index (HDI), life expectancy human development index (HDIL) and percentage of humans living in a poor sanitary condition were obtained through the website of the Brazilian Institute of Geography and Statistics (IBGE, 2015) for the same period than the cysticercosis occurrence data.

The association between the mentioned variables with cysticercosis occurrence in the municipalities was evaluated. Cysticercosis prevalence was dichotomized being considered as negative (0) in municipalities with prevalence included in first quartile (0.00–0.04) and as positive (1) when included in second, third and fourth quartiles. The population density (pop. per km^2) was divided into six categories as 1 (0.30–1.00), 2 (1.01–2.00), 3 (2.01–3.00), 4 (3.01–5.70), 5 (6.20–10.00) and 6 (11.30–241.00). HDI index was divided into three groups: 1 (0.54–0.65), 2 (0.80–0.82) and 3 (0.83–0.85) and HDIL into groups 1(0.76–0.79), 2(0.80–0.82) and 3 (0.83–0.86). Furthermore, the percentage of humans living in a poor sanitary condition was divided into four groups, classified as 1 (29.89–10.35), 2 (9.99–3.16), 3 (2.97–1.21) and 4 (0.96–0.14).

Initially the association was analyzed using logistic regression one variable at a time. Those one in which were observed $p > 0.20$ were evaluated together in a multivariate logistic model. Maps were created using the Terraview® Software.

3. Results and discussion

The prevalence observed among 6,200,497 bovines from the 141 municipalities located in the state of Mato Grosso, during the years

Table 1
Total number of animals slaughtered, total number of cysticercosis cases and controls the prevalence of this disease, the *odds ratio*, 95% confidence interval and the significance level observed in the Administrative Regions from Mato Grosso, Brazil, during the years of 2013 and 2014.

Number	Administrative Regions	Animals slaughtered	Prevalence	Cases	Controls	OR	95% IC OR	P (X2Cor)
7	Juína	444,24	0.03	112	444,128	1	–	–
2	Alta Floresta	751,331	0.03	192	751,139	1.01	0.80 to 1.28	0.96
8	Lucas do Rio Verde	482,928	0.05	250	482,678	2.05	1.64 to 2.57	0.00
12	São Félix do Araguaia	599,64	0.06	330	599,31	2.18	1.76 to 2.71	0.00
9	Matupá	293,084	0.07	197	292,887	2.67	2.12 to 3.36	0.00
11	Rondonópolis	1,161,761	0.07	862	1,160,899	2.94	2.42 to 3.59	0.00
10	Pontes e Lacerda	816,316	0.08	653	815,663	3.17	2.60 to 3.88	0.00
6	Cuiabá	382,566	0.09	334	382,232	3.47	2.80 to 4.29	0.00
3	Barra do Bugres	166,267	0.11	180	166,087	4.30	3.39 to 5.44	0.00
5	Cáceres	744,337	0.15	1094	743,243	5.84	4.81 to 7.09	0.00
1	Água Boa	270,782	0.23	623	270,159	9.14	7.48 to 11.18	0.00
4	Barra do Garças	78,646	0.67	524	78,122	26.60	21.69 to 32.62	0.00
13	Sinop	8599	0.76	65	8534	30.20	22.23 to 41.03	0.00

of 2013 and 2014, was 0.0873% (95% CI 0.0851–0.0897). It is known that the ongoing visual inspection model fails in identifying carcasses with low infection due only the parasite's preferential sites are analyzed (Lopes et al., 2011) and it is a non-selective bias in this research. Out of 5416 detected cysticerci, the calcified ones were more frequent (74.43%) than viable ones (25.57%).

Dutra et al. (2012) found for the same state a prevalence value of 0.12% in the years of 2007–2010. Even if the observed prevalence in this state is low when compared to some other Brazilian states (Dutra et al., 2012), the prevalence found was considered relevant if you take into account the resulting economic losses for the beef supply chain (Schantz et al., 1994).

Rossi et al. (2015) determined prevalence of 2.92%, 1.81%, 1.11% and 0.71% in the states of São Paulo, Minas Gerais, Mato Grosso do Sul and Goiás, respectively. The lower prevalence value found for the state of Mato Grosso is probably explained by the low population density observed in this state (3.36 pop. per km^2) compared with the other states, such as São Paulo (166.23 pop. per km^2), Minas Gerais (33.41 pop. per km^2), Goiás (17.65 pop. per km^2) and Mato Grosso do Sul (6.86 pop. per km^2) (IBGE, 2015).

The high population density turns the presence of infected humans more common consequently increasing the environmental contamination with *Taenia saginata* eggs in these areas, what could infect the animals by the consumption of contaminated water or food, mainly when Good Agricultural Practices are not adopted during animal rearing (Deschamps et al., 2013; Rossi et al., 2015).

Table 1 demonstrates the total number of slaughtered animals, the total number of cysticercoses cases and controls, the prevalence of the disease, the *odds ratio*, the 95% confidence interval and the significance level observed of the 13 Administrative Regions in the state of Mato Grosso, Brazil.

The Administrative Regions of Sinop (OR = 30.20), Barra do Garças (OR = 26.60), Água Boa (OR = 9.14), Cáceres (OR = 5.84), Barra do Bugres (OR = 4.30), Cuiabá (OR = 3.47), Pontes Lacerda (OR = 3.17), Rondonópolis (OR = 2.94), Matupa (OR = 2.67), São Félix do Araguaia (OR = 2.18) and Lucas do Rio Verde (OR = 2.05) had higher risk for cysticercosis occurrence compared with the Administrative Region of Juína, which presented the lowest prevalence (0.03).

The Adminstrative Regions of Sinop, Água Boa, Cáceres, Barra do Bugres and São Félix do Araguaia are known in this state for being a common place for recreational activities near rivers and fishing practices, which are considered risks factors for the occurrence of cysticercosis (Kyvsgaard et al., 1991; Flütsch et al., 2008; Rossi et al., 2015) and help to explain the higher risk found on those areas due to environmental contamination. The contamination of water sources with the parasite's eggs is closely related to touristic areas without proper sanitation system (Flütsch et al., 2008). Therefore, this indicates that the access of the cattle to an uncontrolled water source in these regions must be avoided to control the disease (Rossi et al., 2015), also sanitary education measure to inform the population would help to prevent fecal contamination of the water.

The spatial distribution of cysticercosis prevalence in the 141 municipalities located in the state of Mato Grosso, Brazil, is shown in Fig. 2. The practice of selling and moving animals in Brazilian farms is common during cattle rearing and attributing the last farm location to a case of calcified cyst can probably be a non-selective bias of this study.

Furthermore, logistic regression was performed to evaluate the association between the variables and cysticercosis occurrence in the municipalities. Human population, human density, percentage of humans living in a poor sanitary condition, HDI, area of soy production and cattle population had a p value below 0.20 in the individual analysis, but none of them showed significance ($p > 0.05$) when analyzed in a logistic model. However, a model was constructed using those variables that initially had a p value below 0.05 (percentage of humans living in a poor sanitary condition and population density). Population density remained significant in this model ($p = 0.022$; Likelihood ratio $p = 0.0045$) as shown in Table 2.

The population density explains the observed results, since one *T. saginata* gravid proglottids may produce up to 100,000 eggs and heavily contaminating the environment (CDC, 2016). So, the environmental contamination is higher and allows cattle infection in areas with high population density.

The spatial distribution of bovine cysticercosis in other Brazilian states, such as the states of Paraná and São Paulo (Guimarães-Peixoto et al., 2012; Ferreira et al., 2014) have already been evaluated and high-risk areas are already determined. Furthermore, some risk-based inspection models are being evaluated to improve the quality in the performance of the sanitary inspection (Dupuy et al., 2014; Hill et al., 2014; Calvo-Artavia et al., 2013a, 2013b) since other unusual carcasses sites can be infected with the parasite in low infections (Lopes et al., 2011). So, the development of origin risk-based model to improve cysticercosis detection in endemic countries is required.

4. Conclusions

The bovine cysticercosis prevalence in the state of Mato Grosso, Brazil, was 0.0873% (95% CI 0.0851–0.0897). Some Administrative Regions were identified as high risk of cysticercosis occurrence. Also, our results indicate that areas with high cysticercosis prevalence are linked with the human population density. Furthermore, the results highlight the need of developing an origin risk-based model in order to improve animal and human public health in affected areas, reducing costs of population treatment and economical losses to the beef supply chain.

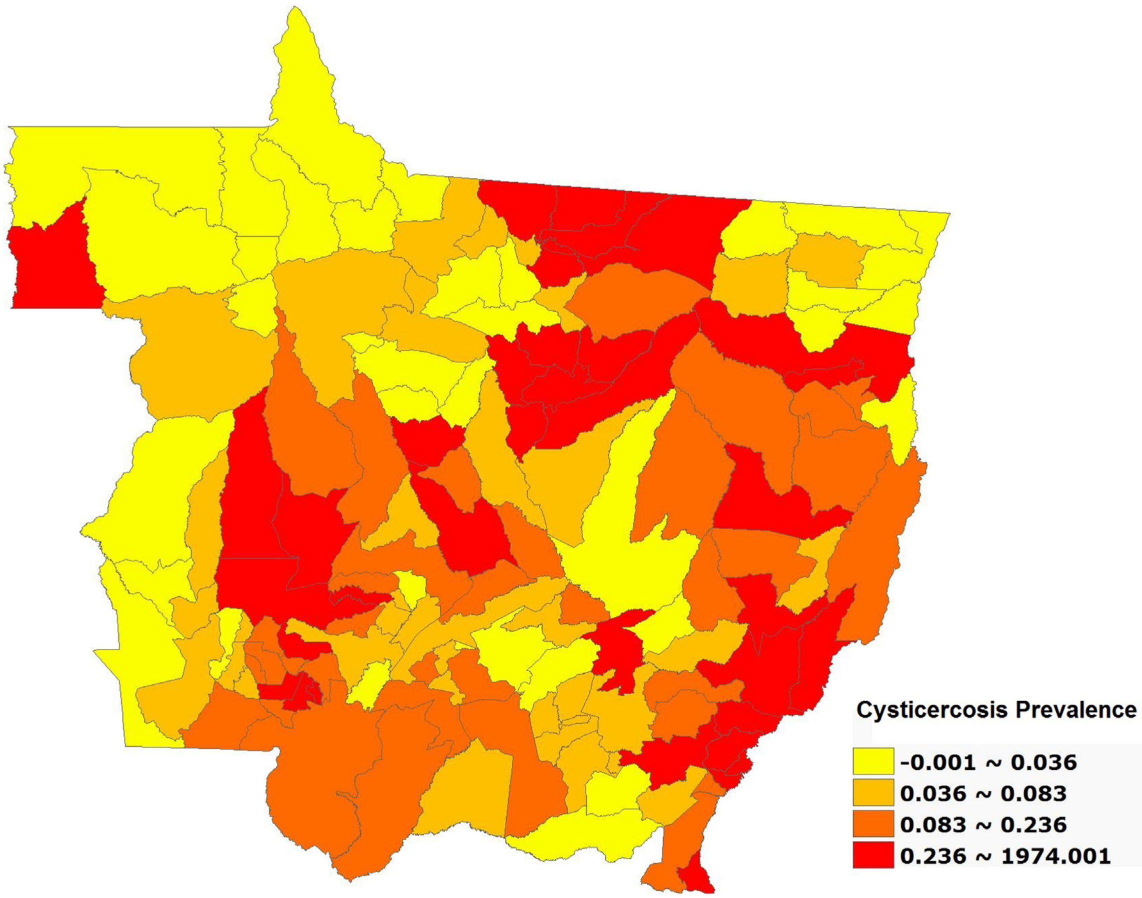

Fig. 2. Geospatial distribution of bovine cysticercosis prevalence in the state of Mato Grosso, Brazil, during the years of 2013 and 2014.

Table 2
Association between cysticercosis prevalence in 141 municipalities in the state of Mato Grosso, Brazil, during the years of 2013 and 2014 with the evaluated variables using logistic regression (p = 0.05).

Variables that had p value below 0.20 during the univariate step Variables	OR	95% C.I	p value
Human Population	1.00	1.00–1.00	0.22
Population Density	1.22	0.87–1.70	0.25
HDI	0.93	0.45–1.94	0.85
Percentage of humans living in a poor sanitary condition	1.33	0.81–2.20	0.25
Cattle population	1.00	1.00–1.00	0.11
Soy production (area)	1.00	1.00–1.00	0.72
Variables that had p value below 0.05 during the univariate step			
Population Density	1.37	1.05–1.80	0.0224
Percentage of humans living in a poor sanitary condition	1.46	0.95–2.24	0.0803

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.prevetmed.2016.06.008.

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