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PARASITOLOGY

Economic losses due to the occurrence of cysticercosis in cattle from cities located in Minas Gerais, Brazil

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ABSTRACT: *Cysticercosis represents an important public health problem that can cause significant economic losses to the beef industry. The present study aimed to determine the prevalence rate of cysticercosis in cattle and estimate the economic losses to producers associated with this parasitic disease. Data were collected from the official sanitary inspection service of a slaughterhouse located in the city of Uberlândia, Minas Gerais, southeast Brazil, from 2009 to 2016. A total of 358,383 cattle from 46 cities in Minas Gerais, Brazil, were slaughtered, of which 4,243 were infected with cysticercosis (1.18%). A total of 5,194 cysticerci were detected in these carcasses, of which 4,548 (87.56%) were alive and 646 (12.44%) were calcified. Most of the cysticerci were located in the masseter and pterygoid masticatory muscles (72.41%). As to the classification of cysticercosis according to the degree of infection of organs and/or parts affected, mild infection was the most frequently observed (92.36%). Rural producers had a total of R$ 1,755,204.20 (US$ 537,526.80) of economic losses due to bovine cysticercosis during the time span of eight years covered by this retrospective study. The importance of the sanitary inspection of meat in the control of this major zoonotic diseases is emphasized.*
Key words: *cysticercus, sanitary inspection of meat, Taenia saginata, zoonosis.*

Perdas econômicas devido à ocorrência de cisticercose em bovinos procedentes de municípios localizados em Minas Gerais, Brasil

RESUMO: *A cisticercose representa um importante problema de saúde pública que pode causar prejuízos econômicos impactantes para a cadeia da carne bovina. Objetivou-se com este estudo determinar a frequência da ocorrência de cisticercose em bovinos e as perdas econômicas aos produtores. Foram coletados dados do serviço de inspeção sanitária oficial de um abatedouro frigorífico de Uberlândia, Estado de Minas Gerais, Brasil, no período de 2009 a 2016. Foram abatidos 358.383 bovinos, provenientes de 46 municípios de Minas Gerais, sendo que destes, 4.243 estavam infectados com cisticercose (1,18%). Foram detectados um total de 5.194 cisticercos, sendo 4.548 (87,56%) vivos e 646 (12,44%) calcificados. A maioria dos cisticercos estava localizada nos músculos mastigatórios masseteres e pterigóides (72,41%). Quanto à classificação da cisticercose, de acordo com o grau de infecção dos órgãos e/ou partes, a infecção discreta foi a que mais ocorreu (92,36%). Verificou-se que os produtores rurais tiveram um total de R$ 1.755.204,20 (US$ 537.526,80) de perdas econômicas durante o período analisado de oito anos devido à ocorrência de cisticercose no rebanho bovino. Destacou-se a importância da inspeção sanitária de carnes, no controle desta importante zoonose.*
Palavras-chave: *cisticercose, inspeção sanitária de carne, Taenia saginata, zoonose.*

INTRODUCTION

Cysticercosis is the most frequently diagnosed zoonotic disease in post mortem examinations of cattle in slaughterhouses in Brazil, and represents an important socioeconomic and public health issue (SANTOS and MOREIRA, 2010). According to SOUZA et al. (2007), losses due to bovine cysticercosis can cause direct economic losses of R$ 24.5 million/year to the country.

The teniasis-cysticercosis complex in cattle occurs in two distinct forms: teniasis which is characterized by human infection with the adult form of *Taenia saginata,* and cysticercosis which is caused by the larval stage of this tapeworm that occur in various bovine organs and tissues. Humans become infected by consuming raw or undercooked beef containing viable cysticerci (CARVALHO et al., 2006).

As for the risk factors for infection with bovine cysticercosis, the following aspects should

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be highlighted in the disease epidemiology: supply of contaminated feed roughage to cattle, use of agricultural land for leisure or tourism, flooding of pastures, socio-economic conditions of the population, free access to surface water bodies (rivers, lakes and canals), as well as proximity to an effluent or waste water source (MAGALHÃES et al., 2017; DUARTE et al., 2016). According to MARSHALL et al. (2016), cattle from farms located near a potential permanent source of human fecal contamination and that use manure from animals other than cattle have a higher risk of developing cysticercosis. MAIA et al. (2017) reported high seroprevalence of bovine cysticercosis in the state of Paraíba and identified as risk factors the purchase of animals and flooded pastures and ROSSI et al. (2015) indicated as risk factors access of cattle to sources of uncontrolled water, as well as sports fishing activities near the farms.

Despite the low sensitivity of the post-mortem examination, especially in mild infections (MINOZZO et al., 2004), MAGALHÃES et al. (2017) emphasized the importance of hygienic-sanitary and technological inspection in obtaining bovine meat. Consumption of raw meat that does not undergo rigorous inspection is considered the main risk factor for the occurrence and maintenance of the of teniasis-cysticercosis complex in cattle.

Cysticercosis remains endemic in Brazil. This important disease is responsible for major economic losses to the beef industry. Therefore, interventions are necessary to keep Brazilian beef competitive on the international food market and to improve food security for the population (ROSSI et al., 2017).

The present study was carried out with the objective of assessing the prevalence of cysticercosis in cattle from cities located in the of Minas Gerais, southeast Brazil, that were sent to a slaughterhouse under official sanitary inspection at the city of Uberlândia, Minas Gerais, Brazil, as well as to estimate economic losses to producers associated with this parasitic disease.

MATERIALS AND METHODS

In this retrospective survey, we used data from the files of the Municipal Inspection Service - SIM which is linked to the Brazilian System of Inspection of Products of Animal Origin - SISBI/POA, which is related to the slaughter of cattle. We collected archived data from a slaughterhouse located in the municipality of Uberlândia, Minas Gerais, in the Southeastern region of the country, from January 2009 to December 2016.

Data on cattle that were slaughtered during this 8-year time span were analyzed, totaling 358,383 animals, including males and females, with ages ranging between 18 to 60 months, from 46 municipalities in the State of Minas Gerais, southeast Brazil, including: Abadia dos Dourados, Água Comprida, Araguari, Araporã, Araxá, Buritizeiro, Campina Verde, Canápolis, Capinópolis, Carmo do Paranaíba, Centralina, Comendador Gomes, Conceição das Alagoas, Coromandel, Douradoquara, Estrela do Sul, Frutal, Gurinhatã, Grupiara, Ibiá, Indianópolis, Iraí de Minas, Itapagipe, Ituiutaba, João Pinheiro, Monte Alegre de Minas, Monte Carmelo, Nova Ponte, Paracatu, Patos de Minas, Patrocínio, Pedrinópolis, Perdizes, Pirapora, Prata, Presidente Olegário, Romaria, Sacramento, Santa Juliana, Santa Vitória, Tupaciguara, Uberaba, Uberlândia, Varjão de Minas, Vazante, and Veríssimo. Cattle identification and traceability was performed based on the Animal Transit Guidelines - GTAs. This system was used to verify the origin of the bovine herd and identify areas with an increased risk for the occurrence of cysticercosis.

Hygienic-sanitary and technological processing of cattle slaughter was carried out as recommended by the following Standards: Meat Inspection - Standardization of Cattle Slaughter Techniques, Facilities, and Equipment of the Brazilian Ministry of Agriculture, Livestock and Supply (BRASIL, 1971) and Regulation of Industrial and Sanitary Inspection of Animal Products - RIISPOA (BRASIL, 2017). For the evaluation and diagnosis of cysticercosis during the post mortem inspection at the slaughterhouse/meat inspection plant, inspection agents from the Municipal Inspection Service – SIM working in slaughter inspection performed palpation and visual examination of the heads, víscera and carcasses of the animals as well as incisions of lymph nodes, masseter muscles, pterygoid muscles, tongue, heart, muscular portion and pillars of the diaphragm, esophagus, and muscles from the front quarter and hindquarter of the carcasses. The carcasses and organs affected by cysticercosis in the inspection lines were retained and diverted to the Department of Final Inspection - DIF for careful examination, classification, judgment, and destination of the meat by the supervising veterinarian/meat inspector from SIM.

Cystic lesions with a translucent or slightly opaque wall, containing clear fluid and a small, round structure inside i.e. the scolex, were considered as living cysticerci. Lesions were interpreted as calcified cysticerci when presented with a fibrous capsule adhered to the surrounding tissue containing a whitish to yellowish material, with a caseous and/or calcareous appearance. As to the degree of infection, cysticercosis was classified as severe when at least eight viable or calcified cysts were found distributed

in the carcass as follows: two or more cysts simultaneously located in at least two selected sites simultaneously located in at least two selected sites of the carcass examined at the slaughter inspection (masticatory muscles, tongue, heart, diaphragm and its pillars, esophagus, and liver), totaling at least four cysts; and four or more cysts located in the forequarter (neck, chest, and palate muscles) or in the rear quarter (thigh, rump, and loin) muscles.

Infection was classified as moderate when more than one viable or calcified cyst and less than that determined for severe infection were reported at the sites of the carcass selected for examination in the slaughter inspection. Infection was classified as mild when only a single viable or calcified cyst was reported at the sites of the carcass selected for examination in the slaughter inspection.

The carcasses and organs in which severe infection was observed were condemned. Discarded specimens were sent to the unit of processing of inedible products. Those classified as having moderate infection had the affected parts removed and condemned and were then destined to conditional use by the use of heat, cooking at a temperature of 76.6°C for at least 30 minutes, or heat melting at a minimum temperature of 12°C. Carcasses and organs in which the infection was classified as mild, the affected sites removed and condemnation and were then subjected to conditional cold treatment at a temperature no higher than -10ºC for at least 10 days. An economic analysis of the losses of farmers related to bovine cysticercosis was made regarding the 25% discount applied for carcasses with mild cysticercosis which were destined to cold thermal treatment, 50% for carcasses with moderate cysticercosis that were destined to heat treatment, and 100% for carcasses with severe cysticercosis which were condemned and destined to the processing unit of inedible products. Arroba values were based on data provided by the Center for Advanced Studies in Applied Economics - CEPEA of ESALQ/USP, Brazil, for the month of December of each corresponding year.

Data on cysticercosis were recorded in specific forms and tabulated in annualized spreadsheets. To estimate the population prevalence, the 95% confidence interval for the proportion (95% CI) was used. Organs and carcasses destined to conditional treatment or condemnation were quantified, and the economic loss of the producers associated with cysticercosis analyzed. The chi-square test of independence was used to assess the relationship between the morphological condition and the anatomical sites affected by *Cysticercus* infection. The binomial test for two proportions was used to compare the amount of live and calcified cysticerci and to analyze the distribution of the cases by anatomical sites. In order to indicate if the prevalence differences were real and not by chance, the chi-square test of adherence was used. All analyses were carried out considering a significance of 5% (AYRES et al., 2005).

RESULTS AND DISCUSSION

The prevalence of bovine cysticercosis was 1.18% (4,243/358,383), with a decrease in these values during the eight years covered by this survey (Table 1). The municipalities with the highest

Table 1 - Prevalence of cysticercosis and the different degrees of infection in cattle from 46 municipalities in the state of Minas Gerais, southeast Brazil, slaughtered under official sanitary inspection between 2009 and 2016.

Year	Number of Slaughtered	----------Cysticercosis----------				
		Number of Cases	Prevalence % (IC 95%)* %	Mild	Moderate	Severe
2009	38,398	820	2.10 (1.90-2.30)	776	32	12
2010	43,670	738	1.69 (1.57-1.81)	713	22	3
2011	35,805	552	1.54 (1.42-1.67)	535	11	6
2012	35,888	417	1.16 (1.06-1.28)	375	35	7
2013	49,138	395	0.80 (0.70-0.90)	372	18	5
2014	54,493	372	0.68 (0.62-0.76)	337	26	9
2015	48,959	516	1.05 (0.97-1.15)	448	46	22
2016	52,032	433	0.83 (0.75-0.91)	363	53	17
TOTAL	358,383	4,243	1.18 (1.15-1.22)	3,919	243	81

*95% CI: Confidence interval at 95% level.

prevalence of bovine cysticercosis in Minas Gerais, southeast Brazil, were Monte Alegre de Minas (4.1%), Tupaciguara (3.8%), and Santa Juliana (2.7%).

ROSSI et al. (2017) carried out a study in 19 Brazilian states between years of 2010 and 2015, and showed a prevalence of 0.62% of bovine cysticercosis. In their study, Paraná (2.01%), Santa Catarina (1.96%), São Paulo (1.77%), Rio Grande do Sul (1.63%) and Mato Grosso do Sul (0.80%) had the highest prevalences of cysticercosis in cattle. PEREIRA et al. (2006) reported a prevalence rate of 1.95% in the State of Rio Janeiro. According to LARANJO-GONZÁLEZ et al. (2016), the prevalence of bovine cysticercosis in most countries in Europe is below 1%. The prevalence of this disease in Belgium based on data published by the official sanitary inspection of that country is estimated at 0.22% (JANSEN et al., 2017). In a study conducted in France by DUPUY et al. (2014), the authors reported a prevalence of bovine cysticercosis of 0.142%. These researchers emphasized the importance of the efficacy in the detection of cysticerci, and suggested the implementation of risk-based inspection procedures in order to improve the prevention of human infection considering the fact that a carcass may infect an average of eight to 20 individuals. Eating habits in France should also be considered. French people usually eat undercooked meat. Consumption of undercooked meat greatly increases the risk of humans becoming infected by viable cysticercus which may go unnoticed during the routine postmortem examination of cattle slaughter inspection.

Masseter and pterygoid muscles were the anatomic sites most affected in the carcasses examined with a prevalence of 72.41% (3,761/5,194), followed by the heart, 19.97% (1,037/5,194), diaphragm, 2.12% (110/5,194),tongue, 1.79% (93/5,194),muscles of the forequarters, 1.47% (76/5,194), esophagus, 1.13% (59/5,194), muscles of the hindquarters, 0.86% (45/5,194), and the liver, 0.25% (13/5,194). In a study conducted by FRUET et al. (2013) in Santa Maria, State of Rio Grande do Sul, south Brazil, the heart was the organ most affected by cysticercosis. In contrast, SOUZA et al. (2007) reported a higher prevalence of the parasite in the muscles of the head (57.77%) followed by the heart (39.65%). Our findings are in agreement with the ones previously published by these authors.

Knowledge on the most frequent sites in which cysticerci occur in bovine carcasses and organs is important in order to improve the efficiency of meat inspection in slaughterhouses. However there remains controversy among authors about the site where this parasite preferentially occurs in cattle (SOUZA et al., 2007). According to COSTA et al. (2012), cysticerci occurs mainly in the muscles that are better irrigated. In the present study, the number of live cysticerci that were reported in the carcasses and organs of cattle during postmortem examination, 87.56% (4,548/5,194), was higher than that of calcified cysticerci, 12.44% (646/5,194), with $p<0.0001$. The chi-square test showed an association between the presence of cysticerci live or calcified and predilection sites in the carcass considered in the diagnosis of this disease during slaughter inspection. There was a significant difference ($p<0.0001$) between frequencies according to the morphological condition and anatomical site (Table 2). In a

Table 2 - Site and morphological condition of cases of cysticercosis detected in cattle slaughtered and inspected in Minas Gerais, Brazil, between 2009 and 2016.

Site/Morphology	--------Live cysticercus-------		-------Calcified cysticercus------	
	N	%	N	%
Masseters and Pterygoids	3,397	74.70	364	56.35
Heart	835	18.36	202	31.28
Diaphragm	94	2.06	16	2.47
Tongue	72	1.58	21	3.25
Foreleg (forelimb, anterior, front quarter, forequarter) muscles	58	1.27	18	2.78
Esophagus	47	1.04	12	1.86
Hind leg (hindlimb, posterior, rear quarter, hindquarter) muscles	34	0.75	11	1.70
Liver	11	0.24	2	0.31
Total	4,548	100	646	100

X^2 for independence=92.25 ($p<0.00001$).

survey carried out in the state of Mato Grosso, Central West Brazil, ROSSI et al. (2016) detected a higher frequency of calcified cysticerci (74.43%). These authors highlighted the need to develop a study model based on risk analysis as to the origin of the animals in order to improve the detection of cysticerci in endemic areas.

GARRO et al. (2015) reported a seroprevalence of 4.10% for bovine cysticercosis and a frequency of 2.94% for human teniasis in the municipality of São João Evangelista, Minas Gerais, southeast Brazil. In their study, consumption of rare beef was the main risk factor for the maintenance of the teniasis-cysticercosis complex. These results are in agreement to those reported by MAGALHÃES et al. (2017) in the municipality of Salinas, Minas Gerais, Brazil.

As to the different degrees of cysticercosis infection, mild infection, 92.36% (3,919/4,243), was the most frequently observed in our study (Table 1). The average weight of the carcasses was 14 arrobas (210kg). We noted that rural producers had a total economic loss of R$ 1,755,204.20 (US$ 537,526.80) due cysticercosis in the bovine herds during the eight years period covered by this survey (Table 3). ROSSI et al. (2015) detected cysticercosis in 58.45% of cattle farms that supplied an export slaughterhouse in the São Paulo, southeast Brazil, in 2012. Estimates of economic losses were US $ 312,194.52.

Post mortem inspection is an important and specific method to identify cysticercosis in cattle during slaughter. This technique, based on the macroscopic Gross detection of live or calcified cysticerci in carcasses and viscera with mild, moderate and severe infections serves as an early warning of the degree of infection in a property or community. It reinforces the importance of sanitary and technological inspection for the control of the teniasis-cysticercosis complex (MINOZZO et al., 2004; PEREIRA et al., 2006).

CONCLUSION

Our findings showed that bovine cysticercosis occur in 46 municipalities of Minas Gerais, southeast Brazil, and demonstrate a prevalence rate of 1.18% of this parasitic disease. Bovine cysticercosis has a direct economic impact on producers who; therefore, can subsidize control measures against this zoonotic disease of major importance in terms of public health.

Table 3 - Simulation of losses (discounts of 25%, 50%, and 100%) generated to rural producers in Brazil due to the occurrence of cysticercosis in bovine herds from 2009 to 2016.

Year	Total weight[1] Mild	Total weight[1] Moderate	Total weight[1] Severe	value R$[2]	Value US$[2]	25% discount R$	25% discount US$	50% Discount R$	50% Discount US$	100% Discount R$	100% Discount US$
2009	10,864	448	168	71	23	192,836	61,219	15,904	5,049	11,928	3,787
2010	9,982	308	42	92	29	229,586	72,894	14,168	4,498	3,864	1,227
2011	7,490	154	84	92	29	172,270	54,696	7,084	2,249	7,728	2,454
2012	5,250	490	98	88	28	115,500	36,671	21,560	6,845	8,624	2,738
2013	5,208	252	70	106	34	138,012	43,812	13,356	4,240	7,420	2,356
2014	4,718	364	126	137	44	161,592	51,296	24,934	7,915	17,262	5,48080
2015	6,272	644	308	145	38	227,360	59,584	46,690	12,236	44,660	11,704
2016	5,082	742	238	148	45	188,034	57,173	54,908	16,695	35,224	10,710
Total	54,866	3,402	1,134	-	-	1,419,890	437,344	198,604	59,728	136,710	40,455

1 – Estimated average weight in 14 arrobas (210Kg).
2 – Market value referring to the month of December of the corresponding year according to CEPEA – Center for Advanced Studies in Applied Economics – ESALQ/USP (Brazil).

DECLARATION OF CONFLICTING INTERESTS

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

AUTHOR' CONTRIBUITIONS

The authors contributed equally to the manuscript.

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