

CAPÍTULO 1 - CONSIDERAÇÕES GERAIS

CAPÍTULO 2 – CISTICERCOSE BOVINA EM ÁREA BRASILEIRA DE PECUÁRIA DE CORTE: UMA NOVA ABORDAGEM

no Brasil:

BOVINE CYSTICERCOSIS IN A BRAZILIAN BEEF CATTLE AREA: A NEW APPROACH

ABSTRACT

Bovine cysticercosis is responsible for economic losses in the beef cattle industry and it is also a public health problem due to taeniasis in human. *Post mortem* inspection is one of the main measures adopted in Brazil for controlling it. Data on bovine carcasses inspections for live and calcified cysts of *Taenia* sp. in slaughterhouses were obtained from the Federal Inspection Service in the period between 2010 and 2012. Additionally, reports of Animal Movement Permits (AMPs) issued in 2012 by the State Agency for Animal and Plant Health Defense of Mato Grosso do Sul were used to build an animal movement network and a cysticercosis incidence map. A total of 413,713 AMPs were issued in 2012, comprising movements of 11,907,436 animals. The total number of animals slaughtered in 2010 was 3,795,887, in 2011 it was 3,604,483 and 4,183,948 in 2012. The incidence of cysticercosis was estimated in 1.20% for 2010, 2.78% for 2011 and 1.09% for 2012. Although cases of bovine cysticercosis were diagnosed in 100% of the municipalities of the Mato Grosso do Sul state in 2012, the highest incidences were seen in the Southern area. The use of relational and geospatial data allowed for constructing an overview of the disease throughout the state, which represents a starting point for adopting mass health education measures to control the disease, especially in regions where higher levels of contamination occur. Measures to control bovine cysticercosis in Brazil would be more efficient if animal traceability was compulsory throughout the country.

Keywords: *Taenia saginata*, Animal Movement Network, Geospatial analysis

1 Introduction

Bovine cysticercosis is a worldwide spread parasitic disease caused by the larval stage of *Taenia saginata* and it is responsible for economic losses in the beef cattle industry. The taeniasis-cysticercosis complex is also a public health issue, especially in developing countries, because its occurrence is associated with poor hygiene habits and the lack of basic sanitation. The *post mortem* inspection and processing of contaminated meat is one of the main measures adopted to prevent human infection. Carcass condemnation by the official veterinary inspection services result in losses that range from 10 to 100 percent of the carcass value (FERNANDES; BUZZETTI, 2001).

Approximately 21 million steers are slaughtered per year in slaughterhouses under Federal Inspection Service (FIS) in Brazil, following strict hygiene guidelines determined by the legislation for inspection of animal's origin products. However, it is still high the percentage of animals that are slaughtered illegally under poor superintendence and conditions, endangering the consumers' health (BRASIL, 2011). (check)

The occurrence of bovine cysticercosis is variable and depends on the region and production system considered. For Mato Grossodo Sul state (MS), Carmo et al. (1997) observed 1.83% of occurrence in the municipality of Três Lagoas, and Marques et al. (2008) observed 4.7% of the analyzed carcasses (MARQUES et al., 2008) in the Midwest region of the São Paulo state, which is next to Mato Grosso do Sul state.

The Brazilian Ministry of Agriculture, Livestock, and Supply (Ministério da Agricultura Pecuária e Abastecimento - MAPA) coordinates all the activities related to veterinary inspection, as well as health defense and surveillance in the country. For this purpose, MAPA delegates to the states, through the State Animal Health Defense Agencies, the control of animal movements by issuing Animal Movement Permits (AMPs) (BRASIL, 2006). These permits are one of the major tools for bovine traceability in Brazil, which allows for tracing back information about movements of batches of animals. A drawback of this system is the inability of tracking information on individuals, which would enable, for example, the identification of sources of bovine cysticercosis. In spite of this limitation, AMPs are still very useful for modeling networks of animal movements, enabling health defense measures (GRISI et al., 2013). Networks of animal movements and animal (?)

traceability are complementary tools, and can be useful for epidemiological studies, as well as for planning disease control and prevention measures.

A network is a set of nodes interconnected by edges. The size of the network is determined by the total number of nodes. The edges linking a pair of nodes can be directed when they harbor relevant information flow from one node to another, as in the case of animals transported between two municipalities (COULON, 2005).

Cattle movement networks can be built considering the origin of purchase and the destination of animals as nodes, and the edges can be weighted by the number of animals moving between two nodes (IPSC, 2010).

Here, data obtained from AMPs were used to build a network of cattle movements for the Mato Grosso do Sul state, Brazil, in 2012. Also, a cysticercosis incidence heatmap map was built for the state based on data on the presence of *Taenia* sp. live and calcified cysts at slaughter, in the period between 2010 and 2012. Put together, the information about animals' movement and cysticercosis incidence can aid the implementation of the control measures.

2 Material and Methods

2.1 Study area

Mato Grosso do Sul is one of the Central-Western states of Brazil. The state includes 79 municipalities, borders five states (Paraná, São Paulo, Mato Grosso, Minas Gerais e Goiás) and two countries (Paraguay and Bolivia), and occupies a prominent position in livestock production and agriculture at national level (IBGE, 2006).

A total of 97,528 rural properties were officially registered at the State Agency for Animal and Plant Health Defense (Agência Estadual de Defesa Sanitária Animal e Vegetal do Estado do Mato Grosso do Sul – IAGRO) with a total of 116,514 landowners and 19,796,351 cattle heads. (Ano 13)

2.2 Data

Data on bovine carcasses inspections for live and calcified cysts of *Taenia* sp. in slaughter houses under FIS were obtained from the Ministry of Agriculture database, for the period of 2010-2012. Simplified reports of AMPs issued in 2012 were obtained from IAGRO.

Data from the last demographic census (IBGE, 2010) was used for the indigenous rural population from Mato Grosso do Sul state.

2.3 Heatmap of bovine cysticercosis

- Bovine cysticercosis incidence heatmaps of the for the Mato Grosso do Sul state, Brazil, were built via areal interpolation, that is, the reassembly of data from a set of polygons (source polygons) to another set of polygons (target polygons) by using the spatial division of municipalities obtained from IBGE (IBGE, 2013). Those were generated by using the open source software and their respective geostatistical and graphical tools R v.3.0.2 (R Development Core Team, 2008), *QGIS* (QGIS Development Team, 2013), Grass (GRASS Development Team, 2012), *TileMill* (TILEMILL Development Team, 2013).

2.4 Animal movement networks

Data on the municipality of origin and destination, purpose, and date of movement were extracted from 413,713 AMPs issued in 2012, corresponding to 11,907,436 bovine being moved. Networks were built and analyzed using the open source softwares *Gephi* (Bastian et al., 2009) and *R* v3.0.2 (R Development Core Team, 2011). Municipalities were represented by nodes and the edges connecting nodes represented the animals moved between municipalities. The municipalities of origin and destination determined the directions of the edges, and its thickness is proportional to the number of animals being moved; a clustering algorithm (InfoMap) that considers this information was used to cluster nodes with narrower relationships regardless their special arrangement.

2.5 Statistical analysis

The Spearman's rank correlation coefficient were used to measure the association between the cysticercosis incidence and the proportion of rural indigenous population with the p-values computed via the asymptotic t approximation by using the *R v3.0.2* (R Development Core Team, 2011) statistical software.

3 Results

The incidence of bovine cysticercosis in the Mato Grosso do Sul state was 1.2 for 2010, 2.78 for 2012 and 1.09 for 2012. The occurrence of bovine cysticercosis was detected in all municipalities of the state and the largest incidence of the disease was observed in the Southern region of the state, which can be interpreted as an endemic region (Figure 1).

A significant ($p < 0.0001$) moderate positive correlation ($\rho = 0.63$) was observed between the occurrence of bovine cysticercosis and the density of indigenous rural population (Figure 2). This indigenous population has higher density in the Central-Southern region of the state, mainly in the municipalities bordering Paraguay, overlapping the municipalities with the highest incidence of the disease.

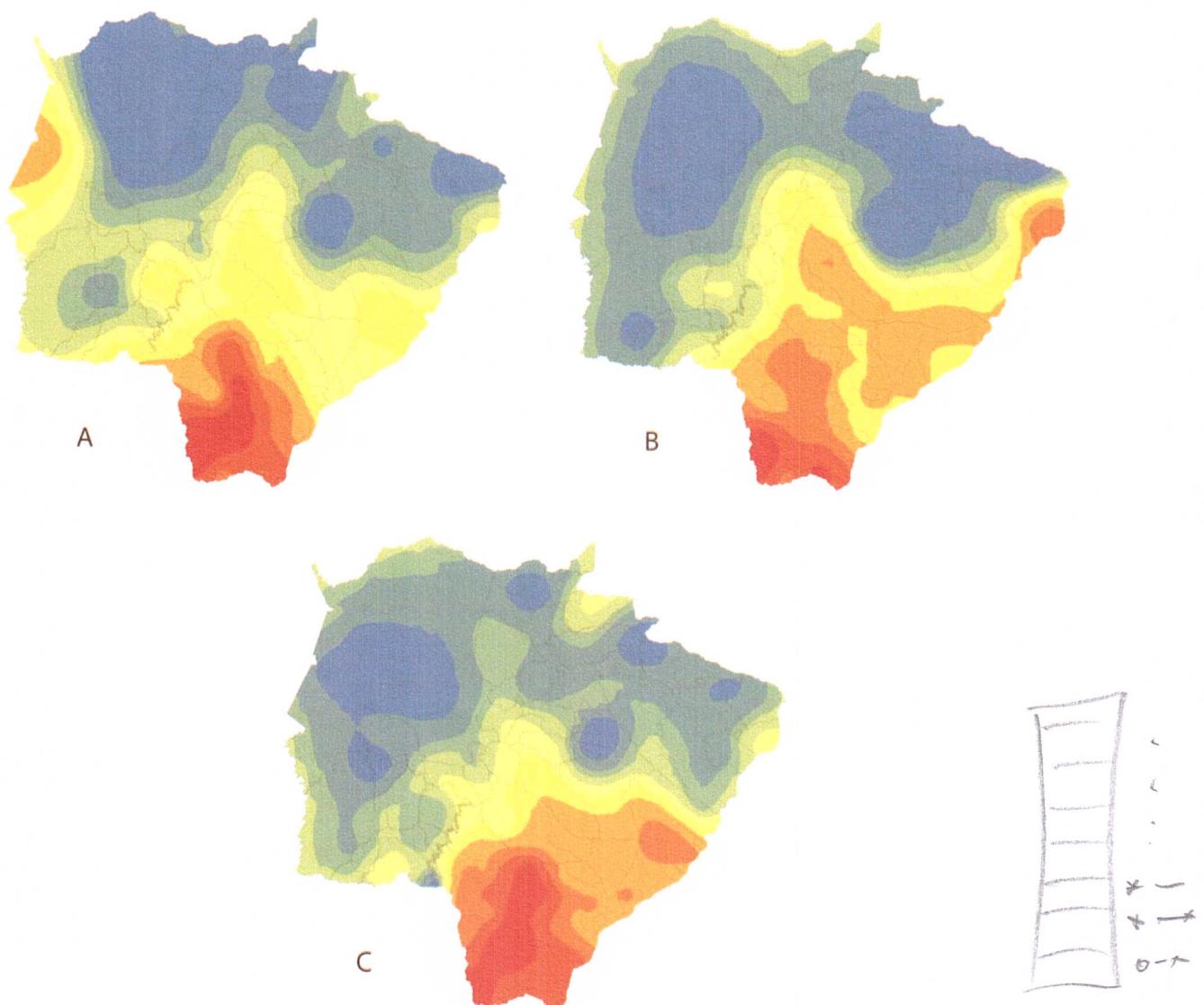


FIGURE 1 – Mapping of bovine cysticercosis in the Mato Grosso do Sul state, Brazil, in 2010 (A), 2011 (B), and 2012 (C). The maps were built by interpolating each dataset. The colors variation corresponds to the intensity of the occurrence of cysticercosis (the warmer the colors, the higher the occurrence).

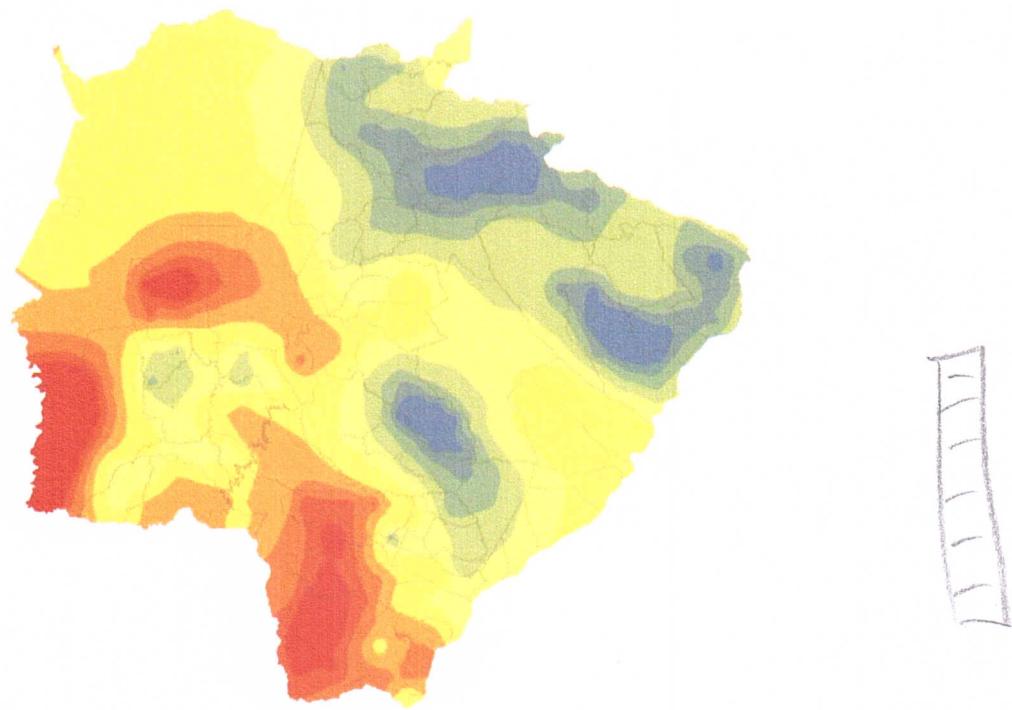


FIGURE 2 – Mapping of rural indigenous population in the Mato Grosso do Sul state, Brazil, in 2012. *Scane*

The general cattle movement network for the Mato Grosso do Sul state in 2012 (Figure 3-A) presents the municipalities' headquarters (nodes) according to their geographical position, and the edges represent the relationship between two points. A total of 5 clusters were found (Figure 3-B), which indicate the regions with preferential trades between nodes. The municipalities exhibiting the largest animal movements are mainly concentrated in the Central and Northwestern region of the state Figure 3-C), which may indicate strategic targets for the control of different diseases.

The animal movements network analysis plotted against the bovine cysticercosis heatmap for the year of 2012 (Figure 3-D) reveals a tendency of higher incidence of the disease in the Southern regions of the state.

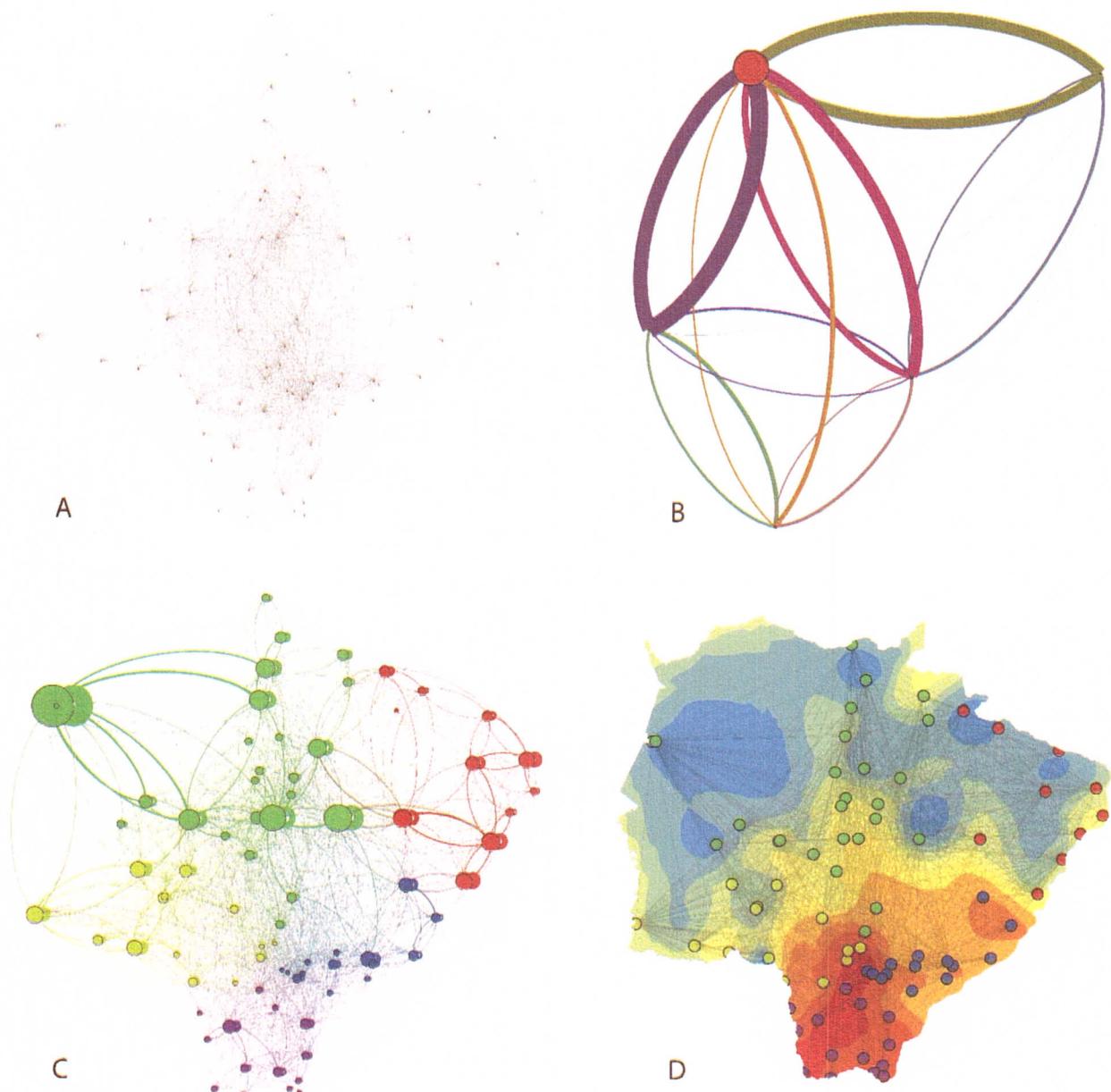


FIGURE 3 – Cattle movement network for the Mato Grosso do Sul state, Brazil (A); clusters of nodes that maintain narrower relationships (B); graphical representation of the cluster of municipalities according to the degree of relationship (nodes of the same color), number of animals moved between two nodes (edge thickness), and weighted degree of income and outcome (node diameter) (C); and composite graph presenting the network of animal movement plotted against the heatmap of bovine cysticercosis for the year of 2012 (D).

4 Discussion

Cattle movement network and cysticercosis incidence heatmap were built based on data from a Brazilian livestock producer state aiming at aiding the planning and implementation of control measures.

In general, Brazilian beef cattle production system is organized in three phases: calves (up to 7-8 months old), steers (around 12 months old) and fattening (> 15 months old), which can be performed in the same farm or in two or three different ones, requiring cattle movement, sometimes between geographically distant regions.

With respect to the animal movement's network in Mato Grosso do Sul state, we observed that the municipalities tend to trade more frequently among themselves and their closest neighbors, due to economic interests and poor transportation infrastructure (specially poor roads). An intense cattle movement in the Central and Northwestern regions of the state was observed possibly due to the fact that these regions, according to data from the Municipal Livestock Production in 2012 (IBGE, 2013), are key regions for cattle fattening (either on pasture or feedlots) as well as beef industrialization in the state, particularly industrial plants licensed for meat export. This observation is also supported by the fact this region is known for its tradition as a supplier of calves and steers, justifying the constant movement of young animals to other areas of the state.

The occurrence of bovine cysticercosis is variable and also depends on the region and production system considered. In the present study, the occurrence of the disease identified in slaughterhouses under federal inspection, increased from 1.1% in 2010 to 2.8% in 2012. A study conducted by Embrapa Beef Cattle in the period between 1974 and 1979, when the state still had few slaughterhouses under federal inspection, resulted in low incidence (1%) of bovine cysticercosis (SCHENK et al., 1982). Latter, Carmo et al. (1997) found an occurrence of 1.8% in steers slaughtered in the municipality of Três Lagoas, MS but another study conducted on steers from the Mato Grosso do Sul state, between 1996 to 2000, resulted in 4.7% positivity of the analyzed carcasses (MARQUES et al., 2008). In the period between 2003 and 2010, Tavares et al. (2012) observed prevalence that ranged from 0.0045% to 6.3% among all municipalities of the state, and observed that the municipalities presenting the highest incidences border Paraguay, in particular Amambai 6.03%, Iguatemi 5.66% and Naviraí 4.68%. These higher incidence at the border as well as the one observed in the Southern region in our study is influenced by many other

factors besides the sanitary ones, like the farm animal density and agriculture activities that demand higher number of hand labor forces.

The highest incidence of bovine cysticercosis in the Southern region of the Mato Grosso do Sul was consistent across the years analyzed, in particular in the bordering region of the state, which presents the highest density of indigenous villages and settlement of “landless workers”.

Aragão et al. (2010) conducted a study where 96 steers were evaluated in two indigenous villages, located in the peripheral area of Dourados, and observed a bovine cysticercosis incidence of 18.75%. Although the indigenous population data analyzed in our study was mainly rural, the poor sanitary conditions of these conservation areas may favors the taeniasis-cysticercosis complex transmission not only in the area but also throughout the surrounding cities due to the informal meat market.

The results observed from the mapping analysis of the distribution of indigenous population in the present study, which correlates positively with the distribution of bovine cysticercosis (Figure 1 – A, B, C and Figure 2), suggest that the Southern region of the state and the indigenous people living in this region are important targets for the control of the disease.

5 Conclusion

The use of relational and geospatial data, as well as the use of methods related to these data types, allowed for building an overview of bovine cysticercosis in the state of Mato Grosso do Sul, highlighting the particular characteristics of each region as well as providing support for planning actions that aim to control, monitor and prevent the disease.

Measures to control bovine cysticercosis in Brazil would be more efficient if traceability was mandatory throughout the country.

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CAPÍTULO 3 - ESTUDO LONGITUDINAL PARA O CONTROLE DA CISTICERCOSE BOVINA EM PROPRIEDADE DE CORTE

LONGITUDINAL STUDY FOR CONTROLLING BOVINE CYSTICERCOSIS IN A BEEF CATTLE FARM

ABSTRACT

Bovine cysticercosis is a problem of worldwide distribution that results in economic losses mainly due to cooling and condemnation of infected carcasses. The difficulty in controlling the disease lies in the epidemiology of it, since man takes role as reservoir and vector, adding social, economic and even cultural factors that make it difficult to control. An animal movement network for a beef cattle farm where cysticercosis occurred was built by using data from the Animal Movement Permits (AMP). In the period between 2011 and 2013 modifications were applied to the existing health management, treatment protocol and, concomitantly, basic sanitary educational activities were implemented. These included lectures, epidemiological inquiries and laboratory tests. Eight farms that had commercial trades were identified by the animal movement Network and characterized as the major contributors for the incidence of cysticercosis in the farm studied. The use of traceability information, along with changes applied to the health management and the sanitarian actions adopted, resulted in a gradual decrease of the cysticercosis incidence from 25% in 2010 to 3.7% in 2011, 1.8% in 2012, and 0.0% in 2013. These results confirm that adequate chemotherapeutic management combined with the animal movement network analysis and health education can contribute for controlling bovine cysticercosis, as well as for minimizing economic losses and prevention of human taeniasis.

Keywords: *Taenia saginata*, treatment and animal movement network

1 Introduction

Trade blocs and countries that import bovine meat from Brazil demand product traceability, especially those included in the Hilton Quota and Traces list, such as the United States of America (USA) and the European Union (EU) (Lopes et al., 2010). For the EU, traceability is mandatory for the authorities to reconstruct the route of an animal product in cases of animal diseases or food poisoning outbreaks that may affect European consumers (UE, 2013).

The traceability process consists in tracing back information of an animal product thru the supply chain by means of recorded identification, which is used to include longitudinal data of an animal to a database. In Brazil, bovine and bubaline traceability follows specific legislation and is coordinated and performed by the Ministry of Agriculture, Livestock, and Supply (Ministério da Agricultura Pecuária e Abastecimento - MAPA), through the Brazilian Bovine and Bubaline Identification and Certification System (Serviço de Rastreabilidade da Cadeia de Bovinos e Bubalinos - SISBOV) (BRASIL, 2012). However, differently from many countries, bovine and bubaline traceability is not mandatory in Brazil. The beef industry that supplies the home market and exports products to countries that do not demand traced products acquires bovines without traceability. Thus, as there is no differential payment for traced animals, the adoption of this system is restricted to few cattle breeders (LOPES et al., 2008).

Currently, Animal Movement Permit (AMP) is one of the main tools for traceability in Brazil. However, AMPs do not allow individual traceability, as they consist of information about animal lots and their movement (GRISI et al., 2013). This system hampers the control of diseases such as bovine cysticercosis, one of the main causes of carcass condemnation in the beef industry that leads to loss in the beef supply chain (MARQUES et al., 2008).

Bovine cysticercosis occurs by the accidental intake of *Taenia saginata* eggs that are present in improperly disposed infected human feces. Thus, carcass condemnation aims at preventing human infection. In beef cattle breeding system in Brazil cows are acquired from multiple farms, implying that the control of the disease must involve fighting infection in the farm of its origin (PEIXOTO et al., 2012). This disease could be controlled through traceability as the process allows gathering data from the origin of an animal by the moment the individual is identified to the entire movement of the animals' life.

The present study aimed at elaborating and executing a strategy to identify and monitor farms with the occurrence of bovine cysticercosis by assessing animal movements of a beef cattle farm that acquires beef cattle from multiple sources.

2 Material and methods

2.1 Studied area

In the state of Mato Grosso do Sul, Brazil, there are 97,528 farms officially registered, adding up 116,514 landowners and 19,796,351 bovines. Currently, the state has the fourth largest herd of the country and livestock is one of its main economic activities (IAGRO, 2013).

During the period between 2011 and 2013, we monitored a beef cattle farm localized in the Três Lagoas municipality ($S\ 20^{\circ}\ 5' \ 20.98''\ W\ 052^{\circ}\ 7' \ 07.49''$) that focuses on the confinement of male steers in feedlots for 30 months. Animals are acquired from multiple sources, and are mainly composed of crossbred dairy steers, aging between 4 and 36 months. These animals are kept in a grazing system with brachiaria pasture, divided into lots of 200 animals until they reach 400 kilograms (kg), and then are finished in feedlots for up to 90 days when they are commercialized with over 530 kg. The animals are fed with a mixture of corn silage, soybean, cottonseed meal, protein and mineral salt. The water provided to the animals is captured from a source that is born in the farm and pumped to a central tank from where it is distributed to the pastures and feedlots. In only three partition, the animals have access to the river and natural weirs.

Thirty-five people inhabit the farm and live in brick houses with treated water and cesspools with septic tanks.

2.2 Bovine cysticercosis treatment

Until 2010, deworming in the studied farm was performed by the subcutaneous application of albendazole sulfoxide 17% (7.5 mg/Kg) in all animals, 30 days before entering the feedlots, with a second dose 30 days after the first dose. In 2011 we implemented a different protocol that comprises 4 subcutaneous applications of albendazole sulfoxide 15% (7.5 mg/kg) 60 and 30 days before entering the feedlot, at the day they enter the feedlot, and 30 days after it. All animals were

slaughtered only after 40 days of the last application, following the manufacturer's recommendation.

2.3 Sanitary education and parasitological survey

Sanitary education activities were conducted in the farm. These involved provision of information about personal hygiene and eating habits, presented in the form of lectures. Stool parasitological examination of feces samples of all inhabitants of the farm was also performed twice under consent and medical prescription, with an interval of 12 months between examinations.

2.4 Bovine movements networks

Based on the data obtained from the farm Animal Movement Permits (AMP), together with data from AMPs of the animal suppliers, an animal movement network was built according to GRISI et al., (2013), using the open source software Gephi 0.8.2 (GEPHI 0.8.2 beta, 2009).

2.5 Sanitary inspection

Animal slaughters were performed in slaughterhouses under Federal Inspection Service (Serviço de Inspeção Federal - SIF), following the guidelines of the Brazilian Sanitary and Industrial Inspection Regulation of Animal Products (Regulamento da Inspeção Industrial e Sanitária de Produtos de Origem Animal – RIISPOA) (BRASIL, 1952).

2.6 Statistical analysis

The difference in the percentage of positivity for cysticercosis over the studied years was assessed by the Two Sample Binomial Proportions test, using the *BioEstat* version 5.3 software (Mamirauá/ Brasil) (AYRES et al., 2007).

3 Results

A total of 4,967 animals were slaughtered between 2010 and 2013. There was a decrease in the occurrence of live cysts cysticercosis and a significant difference ($p \leq 0.0035$) in the percentage of observed live cysts between the studied years was observed (Table 1).

TABLE 1 – Occurrence of cysticercosis in a beef cattle farm in Mato Grosso do Sul, Brazil

Year	Slaughtered bovine (n)	Bovine with live cysts	
		(n)	(%)
2010	742	185	24.9 ^a
2011	837	31	3.7 ^b
2012	2142	39	1.8 ^c
2013	1246	0	0 ^d
Total	4,967	255	5.13

Different letters show statistically significant difference ($p \leq 0.05$)

A positive sample was observed by coproparasitological analysis of the farm workers for the presence of *Taenia* eggs. This patient was treated with niclosamide and a purgative and became negative after that.

Three lectures were given to all farm employees in the studied period, as well as seventeen meetings and nineteen practical lectures of deworming, meat freezing from the slaughtered animals that were to be consumed within the farm, and many visits to the slaughter houses.

Bovine movement network of the farm under study involved 101 municipalities and 7 cluster showing regions with preferential trades (Figure 1). The property presenting the highest animal movements is localized at the municipality of Três Lagoas, MS (30.70%), where the present study was conducted. This highest movement is related to the fact that the landowner has two other farms in the same municipality, which presented intense animal movements between them all year around. Apart from these main routes, the municipality presenting the highest movements is Itaúna-MG, with 27.95% of the total purchased animals (Table 2). Other municipalities with

intense movement were located at states São Paulo (SP), Goiás (GO) and Mato Grosso do Sul (MS).

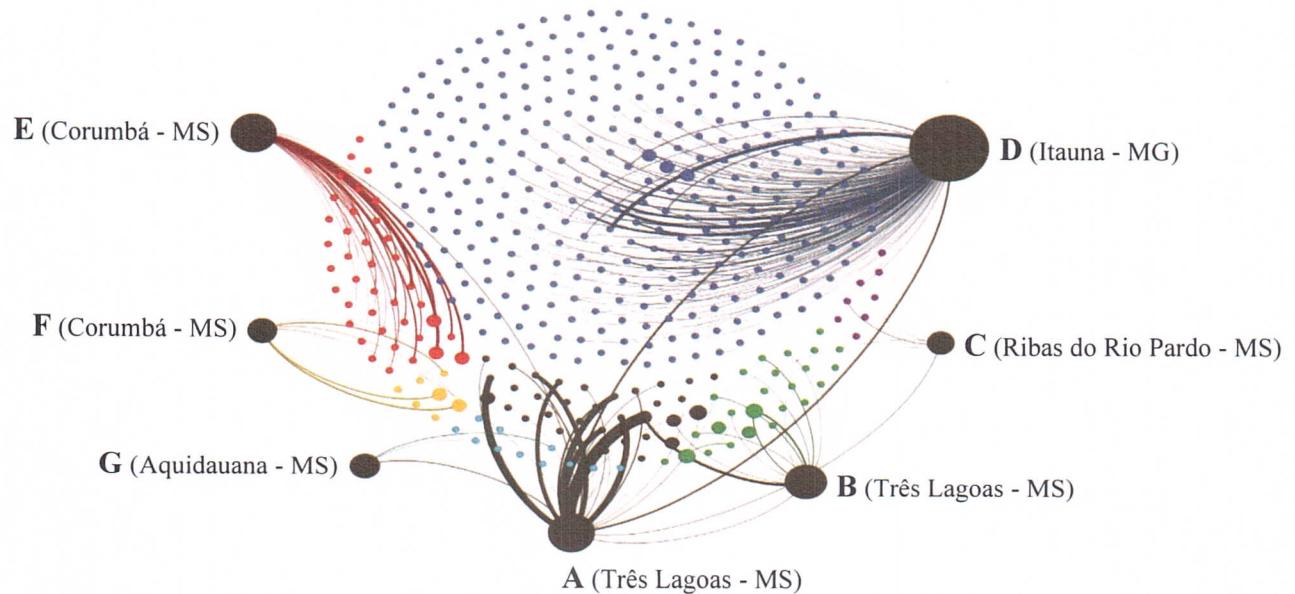


FIGURE 1 – Animal movement network of a beef cattle farm (A) according to the data obtained from the Animal Transit Permits during the period of 2010 to 2012. Each node represents a farm, its diameter indicates the number of animals that entered or left the farm and, each edge, represents the number of animals moved between two nodes. Black nodes maintain relationship with the farm at study (A). The colors of the nodes indicate the group with which it maintained relationship according to the main farm. The letters indicate the municipality where the farms with larger number of moved animals are located.

TABLE 2 – Number of steers (n) and relative percentage (%) that entered the studied farm during 2010-2012 according to its municipality of origin

Municipality	n	%
Três Lagoas, MS	1,980	30.700
Itauna, MG	1,803	27.950
Inocência, MS	1,331	20.640
Presidente Epitácio, SP	315	4.881
Cassilândia, MS	296	4.594
Coxim, MS	267	4.135
Corumbá, MS	191	2.967
Ribas do Rio Pardo, MS	145	2.240
Aquidauana, MS	62	0.957
Holambra, SP	25	0.383
Amparo, SP	21	0.325
Rio Brilhante, MS	6	0.096
Pontes Gestal, SP	4	0.057
Aporé, GO	3	0.038
Bauru, SP	3	0.038
Total	6,452	100

4 Discussion

The main objective of the traceability system is to identify, register and monitor, individually, all cattle born in Brazil (BRASIL, 2002). However, the system based on lots of animals currently used in Brazil hampers individual identification of animals or beef products (ROCHA et al., 2002). The present study reinforce the importance of individual traceability as a tool for efficient control and prevention of bovine cysticercosis.

The prevalence of cysticercosis in the studied farm at the beginning of the study (2010) was 25%, which is similar to the one observed by Souza et al. (2007) in the state of Paraná, probably because most of the slaughtered bovine were also not properly treated. After we started the adequate deworming, as well as using the other control measures at the studied farm, specially avoiding commercial trades with a farm with a higher risk of infection (Figure 2, D), incidence decreased gradually to lower values. Schenk et al. (1982) reported a 1% of bovine prevalence in

Mato Grosso do Sul state between the years 1974 and 1979; Carmo et al. (1997) found a prevalence of 1.8% in the municipality of Três Lagoas, MS; Marques et al. (2008) reported a prevalence of 4.7% for bovine raised in the state of Mato Grosso do Sul; Tavares et al. (2012), in a different study, observed a range of 0.0045% to 6.3% for different municipalities at the same state. During the study, prevalence achieved percentages even lower than the mean prevalence reported by the aforementioned authors.

In the present study, a decrease to 3.7%, 1.8% and 0% was also observed by using albendazole sulfoxide 15%. A similar scenario was observed after the introduction of chemotherapy in a feedlot farm localized in the municipality of Goiânia (GO) were the initial occurrence of bovine cysticercosis was 37.5% and the chemotherapy resulted in a decrease to 4%, 1% and 0% after three treatments using albendazole sulfoxide 17% (BIONDI et al., 1999).

Data obtained from a beef cattle farm together with the information registered on the Animal Movement Permits (AMP) about the farms where the cattle was last located and to where it was destined, allowed us to observe a high influx of animals from several municipalities (Figure 1). The mean age of the animals acquired in the year of 2012 (data not shown), was between 25 and 36 months, indicating that these animals stayed for a shorter period of time in the farm, which suggests that these animals were already infected before entering the property. Thus, besides bovine treatment and sanitary educational measures, by using the cattle movement network we could identify farms with putative risk that had commercial trades with the studied one and, by avoiding purchasing animals from one of them, occurrence of cysticercosis gradually fell down.

5 Conclusions

The identification of farms with putative risk of *Taenia saginata* infection by the animal movement network and traceability, the implementation of sanitary education in the farms are useful tools for controlling and preventing bovine cysticercosis, minimizing economic losses and preventing human taeniasis.

We suggest that individual bovine traceability should be a mandatory sanitary standard for the control of animal and zoonotic diseases.

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