

UNIVERSIDADE ESTADUAL PAULISTA
“JÚLIO DE MESQUITA FILHO”
FACULDADE DE MEDICINA VETERINÁRIA
CAMPUS DE ARAÇATUBA

**ESTUDO EPIDEMIOLÓGICO DO COMPLEXO TENÍASE-
CISTICERCOSE: NOVAS ABORDAGENS**

Samuel Carvalho de Aragão
Médico Veterinário

ARAÇATUBA – SP

2014

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CISTICERCOSE: NOVAS ABORDAGENS**

Tese de Doutorado apresentada junto ao
Curso de Pós-graduação em Ciência
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Preventiva para obtenção do título de
Doutor.

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Orientadora: Profa. Dra. Adj. Cárís Maroni Nunes

ARAÇATUBA – SP

2014

DADOS CURRICULARES DO AUTOR

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EPÍGRAFE

Sobre tudo o que se deve guardar, guarde o teu coração, porque através dele você
verá à DEUS, Provérbios 4:23

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LISTA DE ABREVIATURAS

ADEPARÁ =	Agência de Defesa Sanitária Animal do Estado do Pará
APTA =	Agência Paulista de Tecnologia dos Agronegócios
BA =	Bahia
CNPq =	Centro Nacional de Pesquisa
EUA =	Estados Unidos da América
FMVA =	Faculdade Medicina Veterinária de Araçatuba
GTA =	Guia de Trânsito Animal
IAGRO =	Agencia Estadual de Defesa Sanitária Animal e Vegetal do Mato Grosso do Sul
IFPA =	Instituto Federal do Pará
Kg/PV =	Quilograma por peso vivo
LBBMA =	Laboratório de Bioquímica e Biologia Molecular
MAPA =	Ministério da Agricultura Pecuária e Abastecimento
MG =	Minas Gerais
Mg/Kg =	Miligramas por quilograma
MS =	Mato Grosso do Sul
OIE =	Organização Internacional de Epizootias
RS =	Rio Grande do Sul
SC =	Subcutânea
SIF =	Serviço de Inspeção Federal
SISBOV =	Sistema de Rastreabilidade da Cadeia de Bovinos e Bubalinos
SP =	São Paulo
STAEP =	Sessão Técnica de Apoio ao Ensino. Pesquisa e Extensão
UE =	União Europeia
UFLA =	Universidade Federal de Lavras
UNESP =	Universidade Estadual Paulista
UNIGRAN =	Universidade da Grande Dourados
USP =	Universidade de São Paulo

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ESTUDO EPIDEMIOLÓGICO DO COMPLEXO TENÍASE-CISTICERCOSE: NOVAS ABORDAGENS

RESUMO

A cisticercose bovina é a principal causa de condenação de carcaças nas indústrias frigoríficas do Brasil, provocando grandes perdas econômicas na cadeia produtiva da carne. Até o momento, não há no Brasil uma vacina comercial ou a perspectiva de um anti-helmíntico mais eficaz para o controle desta parasitose. Este problema é agravado pelo sistema de produção da carne no Brasil e pelas características epidemiológicas desta zoonose, onde o homem assume importante papel na transmissão desta para o animal, dificultando seu controle. Embasado na perspectiva de obter melhor controle sobre esta enfermidade, o presente estudo objetivou avaliar a movimentação de bovinos e o mapa de ocorrência da cisticercose bovina no estado do Mato Grosso do Sul, através de dados das guias de Trânsito Animal, associados aos dados de abate e condenação de carcaças por cisticercose bovina do estado. O uso destas novas abordagens possibilitou visualizar a distribuição da doença, identificar áreas de maior ocorrência e sugerir medidas pontuais de controle, minimizando as perdas econômicas que esta provoca em sua cadeia de produção.

Palavras-chave: Complexo teníase-Cisticercose, Inspeção sanitária, Rede de movimentação animal

EPIDEMIOLOGIC STUDY OF THE TENIASIS-CYSTICERCOSIS COMPLEX: NEW APPROACHES

ABSTRACT

Bovine cysticercosis is the main cause of carcass condemnation in the Brazilian beef cattle industry and it is responsible for large economic losses in the meat production chain. Up to now, there is no commercial vaccine in Brazil or a more effective anthelmintic to control this disease. This problem is impaired by the Brazilian beef cattle production system as well as by the epidemiological characteristics of this zoonosis, where the man plays an important role for its transmission to cattle. Based on the perspective of better controlling this disease. the present study aimed to construct a cattle movement network and a map of bovine cysticercosis occurrence in the Mato Grosso do Sul state, based on data of the Animal Movement Permits and of bovine cysticercosis carcass condemnation. This approaches allowed us to analyze the diseases' distribution, to identify areas of high occurrence and to suggest punctual control measures minimizing the economic losses this disease causes in its production chain.

Keywords: Teniasis-cysticercosis complex, Sanitary inspection, Animal movement network

CAPÍTULO 1 – CONSIDERAÇÕES GERAIS

A cisticercose bovina é uma doença parasitária causada pela forma larvar (metacestóides) da *Taenia saginata*, com ocorrência mundial, em especial nos países em desenvolvimento, acarretando grandes prejuízos na cadeia da carne. Em bovinos, os metacestóides de *Taenia saginata* se desenvolvem nos tecidos, principalmente naqueles de maior irrigação sanguínea, como os músculos cardíaco e os masseteres. A forma adulta do parasita se instala no intestino delgado do homem quando este ingere carne contendo as formas metacestóides, caracterizando a teníase. A enfermidade é considerada uma antropozoonose verdadeira, na qual o homem é o hospedeiro definitivo e animais domésticos, como o bovino, hospedeiros intermediários. O complexo teníase-cisticercose é também um problema de saúde pública difundido principalmente nos países em desenvolvimento, cuja população em geral tem baixo nível socioeconômico e educacional, o que reflete em hábitos precários de higiene (OIE, 2008).

O homem é infectado ao ingerir alimentos contendo cistos do parasita. Em geral a carne não inspecionada. A inspeção *post mortem* e o tratamento físico da carne, são medidas que visam prevenir a teníase humana. Sendo uma enfermidade que tem o homem como agente transmissor, seu controle e erradicação são difíceis devido à migração humana, o que torna a cisticercose uma doença de ocorrência mundial.

1.1 Distribuição global da cisticercose bovina

Apesar da rigorosa legislação que regula o sistema de inspeção de carnes na Europa, a *Taenia saginata* ainda está presente no continente Europeu, causando perdas econômicas devido à condenação e tratamento de carcaças infectadas. As principais razões para essa persistência incluem a deficiência nos protocolos para com a inspeção da carne importada, disseminação e sobrevivência de ovos no meio ambiente, sistemas de criação em pastagens e contaminação das fontes de água por efluentes humanos, sugerindo que os fluxos de água e a água de superfície são potencialmente contaminados com ovos do parasita. Além disto, o tratamento precário

dos efluentes contribui para a disseminação dos ovos no meio ambiente (DORNY; PRAET 2007).

Na Europa, foram observadas taxas de prevalência entre 0,01 e 10% com as taxas mais altas na Eslováquia (CABARET et al., 2002). No entanto, é difícil comparar a prevalência entre diferentes países, pois estes possuem métodos de diagnósticos e legislações distintas sobre o tema.

Na Austrália, Nova Zelândia e Estados Unidos os sistema de criação de bovinos são muito parecidos, com grandes propriedades que manejam os animais em sistema extensivo de criação e regime de engorda em sistema intensivo. Em diversas regiões os bovinos são criados em regime extensivo, porém as condições de saneamento e educação sanitária, bem como o serviço de inspeção são melhor estruturados e favorecem a manutenção de uma baixa prevalência da doença, atingindo menos de 0,5% das carcaças examinadas (SANTOS FILHO, 2000).

No continente Africano, as áreas de alta endemicidade incluem os países da África Central e Oriental com destaque para a Etiópia, Quênia e Zaire. Áreas endêmicas ocorrem na Ásia, Cáucaso, na região centro-sul da antiga União Soviética e no Mediterrâneo (Síria, Líbano e Iugoslávia). Em alguns locais até 65% das pessoas foram relatadas como sendo hospedeiros da *Taenia saginata*. Por outro lado a Ásia, Tailândia, Vietnã, Filipinas, Índia, Japão e países da América do Sul apresentam uma prevalência moderada da doença (LLOYD, 1998).

Na América do Sul a cisticercose bovina está presente em todos os países e principalmente naqueles onde as condições de higiene da população são precárias. nestes a incidência da doença chega a ultrapassar 20%. Devido a problemas que envolvem questões sócios-culturais e deficiências no tocante à educação sanitária, estes índices tem se mantido e vem provocando grandes prejuízos na cadeia produtiva da carne na América do Sul e preocupação para as autoridades sanitárias (MIRANDA, 2002).

1.2 Cisticercose bovina no Brasil

No Brasil a cisticercose bovina está presente em todos os estados. A condenação pelo serviço de inspeção resulta em perdas entre 10 a 100% do valor das carcaças (FERNANDES; BUZETTI 2001), No estado do Mato Grosso do Sul, por exemplo, estima-se que as perdas causadas pelo diagnóstico *post mortem* da cisticercose bovina no período de 2010 a 2012, em média foi de a USD 9.000.000. Devido a esses entraves existentes na pecuária, a cisticercose bovina resulta em marketing negativo da carne brasileira (SANTOS et al., 2008).

1.3 Cisticercose bovina no estado do Mato Grosso do Sul

O estado do Mato Grosso do Sul (MS) localiza-se na região centro-oeste do Brasil, é constituído por 79 municípios e faz divisa com cinco estados brasileiros (Paraná, São Paulo, Mato Grosso, Minas Gerais e Goiás) e 2 países (Paraguai e Bolívia). Tem na produção agropecuária sua principal atividade econômica, ocupando posição de destaque em nível nacional (IBGE, 2006). A cisticercose bovina está presente em todo o estado do Mato Grosso do Sul e sua ocorrência é variável, na dependência da região e do sistema de produção. Estudo realizado no período de 1974 a 1979 pela Embrapa Gado de Corte de Campo Grande, MS, na época em que o estado possuía poucos matadouros frigoríficos com Serviço de Inspeção Oficial revelou 1% de ocorrência de cisticercose bovina (SCHENK et al., 1982).

Carmo et al. (1997) observaram ocorrência de 1,83% de cisticercose em bovinos do Mato Grosso do Sul abatidos em um matadouro frigorífico com Serviço de Inspeção Federal (SIF) localizado no município de Três Lagoas. Outro estudo realizado com bovinos abatidos na região centro oeste do estado de São Paulo mas provenientes do estado de Mato Grosso do Sul, no período de 1996 a 2000, resultou em 4,7% de positividade para cisticercose ao abate (MARQUES et al., 2008).

Lolatto et al. (2012) citam que a prevalência de cisticercose no estado de Mato Grosso é de 1,46%. No período entre 2003 a 2010, Tavares et al. (2012) observaram ocorrência que variou entre 0,0045% a 6,0278% entre todos os municípios do estado,

sendo que aqueles que apresentaram maiores percentuais encontravam-se próximos a fronteira com o Paraguai, com destaque para Amambaí 6,03% (2005), Iguatemi 5,66% (2010) e Naviraí 4,68% (2008).

1.4 Inspeção, vigilância e defesa sanitária no estado do Mato Grosso do Sul

O principal meio diagnóstico da cisticercose bovina é através da inspeção *post mortem* nos matadouros frigoríficos com o Serviço de Inspeção Federal, Estadual e Municipal. De acordo com o artigo 176 do Regulamento de Inspeção Industrial e Sanitária de Produtos de Origem Animal (BRASIL, 1952), na inspeção sanitária realizada nas indústrias frigoríficas com o registro no serviço de inspeção oficial (Federal, Estadual e Municipal) o método diagnóstico mais utilizado para a detecção da cisticercose bovina (BRASIL, 1997). Este diagnóstico consiste em cortes na musculatura da cabeça (músculos masseteres e pterigoideos externos e internos), esôfago, língua, coração e diafragma para pesquisar a presença de cistos.

O papel da inspeção sanitária de carne realizada nos matadouros frigoríficos oficiais é de grande importância para a saúde pública, retirando do mercado carnes impróprias ou potencialmente prejudiciais ao consumo humano. Com isto, a prevenção da teníase humana pode ser alcançada uma vez que carcaças e órgãos de bovinos parasitados são adequadamente destinados (MONTEIRO et al., 2006),

Cerca de 21 milhões de bovinos são abatidos por ano em estabelecimentos com serviço de Inspeção Federal em condições adequadas de higiene e que estão de acordo com as legislações vigentes de Inspeção de Produtos de Origem Animal. porém, é alto o percentual de abates clandestinos, onde os animais são abatidos em locais com condições precárias ou sem nenhum tipo de controle, colocando em risco a saúde do consumidor (BRASIL, 2011).

O Ministério da Agricultura Pecuária e Abastecimento (MAPA), coordena todas as atividades de Inspeção, Defesa e Vigilância Sanitária no Brasil. Para isto, delega aos estados, através das Agências Estaduais de Defesa Sanitária Animal, o controle do trânsito animal com a emissão das Guias de Trânsito Animal (GTAs) (BRASIL, 2006). A GTA é hoje uma das principais ferramentas de rastreabilidade no Brasil, permitindo

rastrear o lote de animais e fornecendo informações de movimentação animal entre as propriedades.

A Agência Estadual de Defesa Sanitária Animal e Vegetal do Estado do Mato Grosso do Sul (IAGRO) é responsável pelo serviço de defesa agropecuária do estado, com sede central localizada no município de Campo Grande, e sedes regionais distribuídas em municípios estratégicos de maneira a facilitar as atividades operacionais da agência de defesa (IAGRO, 2013). O IAGRO possui noventa e um escritórios de atendimento nos setenta e nove municípios do MS, divididos entre dezesseis escritórios regionais, coordena dezenove frigoríficos com o registro no Serviço de Inspeção Estadual. No estado, 97.528 propriedades rurais são oficialmente cadastradas no IAGRO, totalizando 116.514 proprietários e 19.796.351 cabeças de bovinos. Atualmente o estado detém o quarto maior rebanho do país, sendo a pecuária uma de suas principais atividades econômicas (IAGRO, 2013).

1.5 Dificuldades no Controle da Cisticercose Bovina no Mato Grosso do Sul

É complexa a problemática envolvendo o controle da cisticercose bovina no Brasil como um todo, uma vez que a doença não é de notificação obrigatória e o país não possui um programa oficial de controle e erradicação da cisticercose bovina e suína. O problema é agravado pela falta de saneamento básico e pobreza da população de algumas áreas. Esta situação é bastante evidenciada na região de fronteira com o Paraguai e Bolívia (SOUCHAUD, 2008), agravada pelos problemas sociais de acampamentos de trabalhadores sem-terra, mão de obra humana utilizada nas usinas de cana de açúcar, muitas delas sem infraestrutura adequada para os trabalhadores, condições precárias de vida dos povos indígenas nas aldeias próximas das áreas urbanas ou de regiões onde estão aglomeradas as principais áreas de criação de bovinos do estado (ARAGÃO, 2010).

Por ser um importante exportador de carnes, atendendo mercados importantes como a União Europeia, o estado do Mato Grosso do Sul tem incentivado os criadores a adotarem a rastreabilidade dos animais, o que facilita a comercialização destes para grandes redes de frigoríficos, agregando valor a seus produtos. Entretanto, a

rastreabilidade no Brasil não é obrigatória, o que dificulta o controle da cisticercose, devido à falta de informações acerca da origem dos bovinos para a identificação de áreas de foco da doença, e grande parte dos criadores adquire animais não rastreados.

2 Objetivos

2.1 Objetivo geral

Utilizar a rede de movimentação de bovinos de corte do estado do Mato Grosso do Sul como exemplo de ferramenta epidemiológica, com o intuito de sugerir estratégias de controle para a cisticercose bovina.

2.2 Objetivos específicos

- construir a rede de movimentação dos bovinos no Mato Grosso do Sul a partir das GTAs;
- elaborar o mapa de ocorrência (*heat map*) da cisticercose no estado do Mato Grosso do Sul;
- correlacionar a distribuição da doença com a rede de movimentação dos animais;
- testar possíveis estratégias para o controle da cisticercose bovina.

3 Referências

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CAPÍTULO 2 – CONTROLE DA CISTICERCOSE BOVINA EM ÁREA DE PECUÁRIA DE CORTE NO BRASIL: UMA NOVA ABORDAGEM

BOVINE CYSTICERCOSIS CONTROL ON 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. Cysticercosis prevalence 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 to have an overview of the disease throughout the state, which represents a starting point to adopt mass health education measures to control this zoonosis, especially in regions where higher levels of contamination occur.

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; BUZETTI, 2001).

Approximately 21 million bovines are slaughtered per year in slaughterhouses under Federal Inspection Service (FIS) in Brazil, following strict hygiene guidelines determined by the Brazilian legislation for inspection of products from animal origin. However, it is still high the percentage of animals that are illegally slaughtered under inadequate conditions and without sanitary inspection, endangering the consumer's health (BRASIL, 2011).

The occurrence of bovine cysticercosis is variable and depends on the region and production system considered. For Mato Grosso do Sul state 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 in the São Paulo state Midwest region, which is near to the studied area.

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 the health defense and surveillance ones in the country. For this purpose, MAPA delegates to the states 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, allowing to trace back information about animal cargo displacement. A drawback of this system is the inability of tracking information individually, which would enable, for example, the identification of sources of bovine cysticercosis. In spite of this limitation, AMPs are still very useful for modeling animal movement networks, enabling health defense measures (GRISI et al.,

2013). Networks and animal traceability are complementary tools that can be useful for epidemiological studies, as well as for planning disease control and prevention measures. Put together, the information about animals' movement and cysticercosis incidence can aid the implementation of bovine cysticercosis control measures.

Here, data obtained from AMPs were used to construct a cattle network movement for the Mato Grosso do Sul state, Brazil, in the year of 2012. Also, a cysticercosis incidence heat map was constructed for the state based on data of the presence of *Taenia* sp. live and calcified cysts at slaughter, in the period between 2010 and 2012.

2 Material and Methods

2.1 Study area

Mato Grosso do Sul is one of the Central-Western states of Brazil that occupies a prominent position in livestock production and agriculture at national level. The state includes 79 municipalities, borders five states (Paraná, São Paulo, Mato Grosso, Minas Gerais e Goiás) and two countries (Paraguay and Bolivia) (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 bovine in 2012. Currently, the state has the fourth largest cattle herd of the country and livestock production is one of its main economic activities (IAGRO, 2013).

2.2 Data

Data on bovine carcasses inspections for live and calcified cysts of *Taenia* sp. From 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 as well as for variables like settlement population, sugar cane workers sewage disposal system and population density.

2.3 Bovine cysticercosis heat map

Mapping the bovine cysticercosis occurrence for the Mato Grosso do Sul state was done by calculating the proportion of infected animals according to its origin and plotting it against the spatial division of the municipalities obtained from the Brazilian Geographic and Statistics Institute- IBGE (IBGE. 2013). A color progression was used to represent the density in each area. Those were generated by using the open source softwares R v.3.0.2 (R Development Core Team, 2011), QGIS (QGIS Development Team, 2013), Grass (GRASS Development Team, 2012), *TileMill* (TILEMILL Development Team, 2013) and their respective geostatistical and graphical tools.

2.4 Animal movement networks

Data on the municipality of origin and destination, purpose, and date of the cattle movement were acquired 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). Nodes represented municipalities 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 geographic arrangement. This algorithm measures, on each step, the average code length that describes a random walker's movement on a network, determining the community of each node by assigning it to a module that minimizes its length. That is, nodes close to each other would share and facilitate the information flow reducing the complexity necessary to describe the network (ROSVALL; BERGSTROM. 2008). We

used the R implementation of this algorithm included in the *igraph* package. using as input the network data. the edges weights (number of animals moved between two nodes). the number of attempts to partition the network (setted to 1000) and assumed that each node has the same weight (CSARDI; NEPUSZ. 2006).

2.5 Statistical analysis

The Spearman's rank correlation coefficient were used to measure the association between the cysticercosis incidence and variables (indigenous rural population. settlement population. sugar cane workers. sewage disposal system and population density) obtained from the IBGE database (IBGE. 2006; IBGE. 2010; IBGE 2013) with 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 in 2010, 2.78 in 2012, and 1.09 in 2012. The occurrence of bovine cysticercosis was detected in all municipalities of the state and the largest and constant 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 ($\rho = 0.63$) between the occurrence of bovine cysticercosis was observed only for the proportion of indigenous rural population. which has higher density in the Central-Southern region of the state. mainly in the municipalities that border Paraguay. overlapping some of the municipalities with the highest incidence of the disease in this region. No significant correlations was seen between the cysticercosis incidence and the other studied variables.

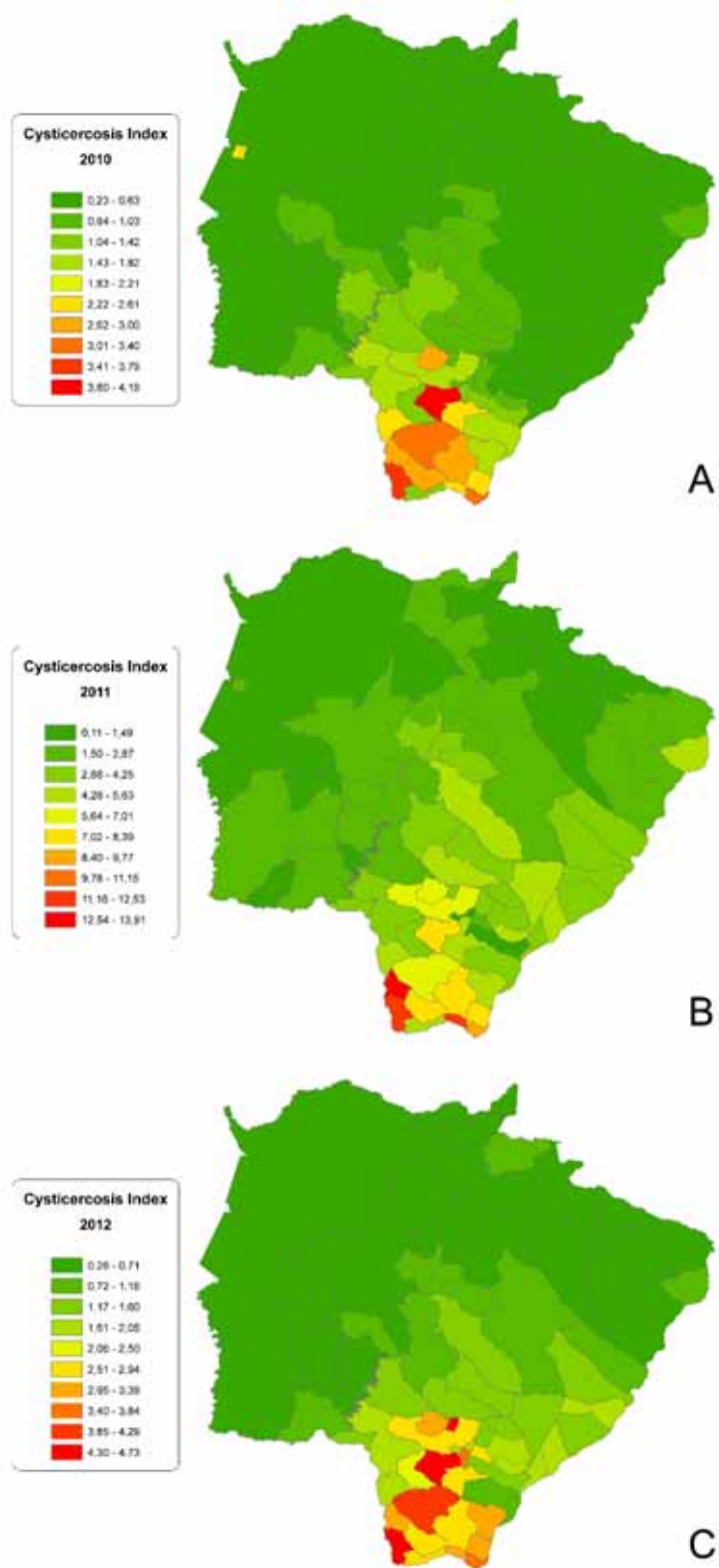


FIGURE 1 – Mapping of bovine cysticercosis occurrence in the Mato Grosso do Sul state, Brazil, according to the municipalities during the year 2010 (A), 2011 (B) and 2012 (C).

A general cattle movement network for Mato Grosso do Sul state during the year of 2012 was constructed showing an intense movement within the state (Figure 2-A). Five clusters can be observed (Figure 2-B) indicating the regions with preferential trades between nodes. The municipalities exhibiting intense animal movement (nodes diameter) are mainly concentrated in the Central and Northwestern region of the state (Figure 2-C), which can be used as strategic target for the control of different cattle diseases, including cysticercosis.

The cattle movement network plotted against the bovine cysticercosis heat map for the year of 2012 (Figure 2-D) allows the observation that the higher incidence of the disease in the Southern region of the state is limited to one of the clusters. Health educational measures and proper treatment of the cattle target to this cluster could be of great value to control bovine cysticercosis in this area.

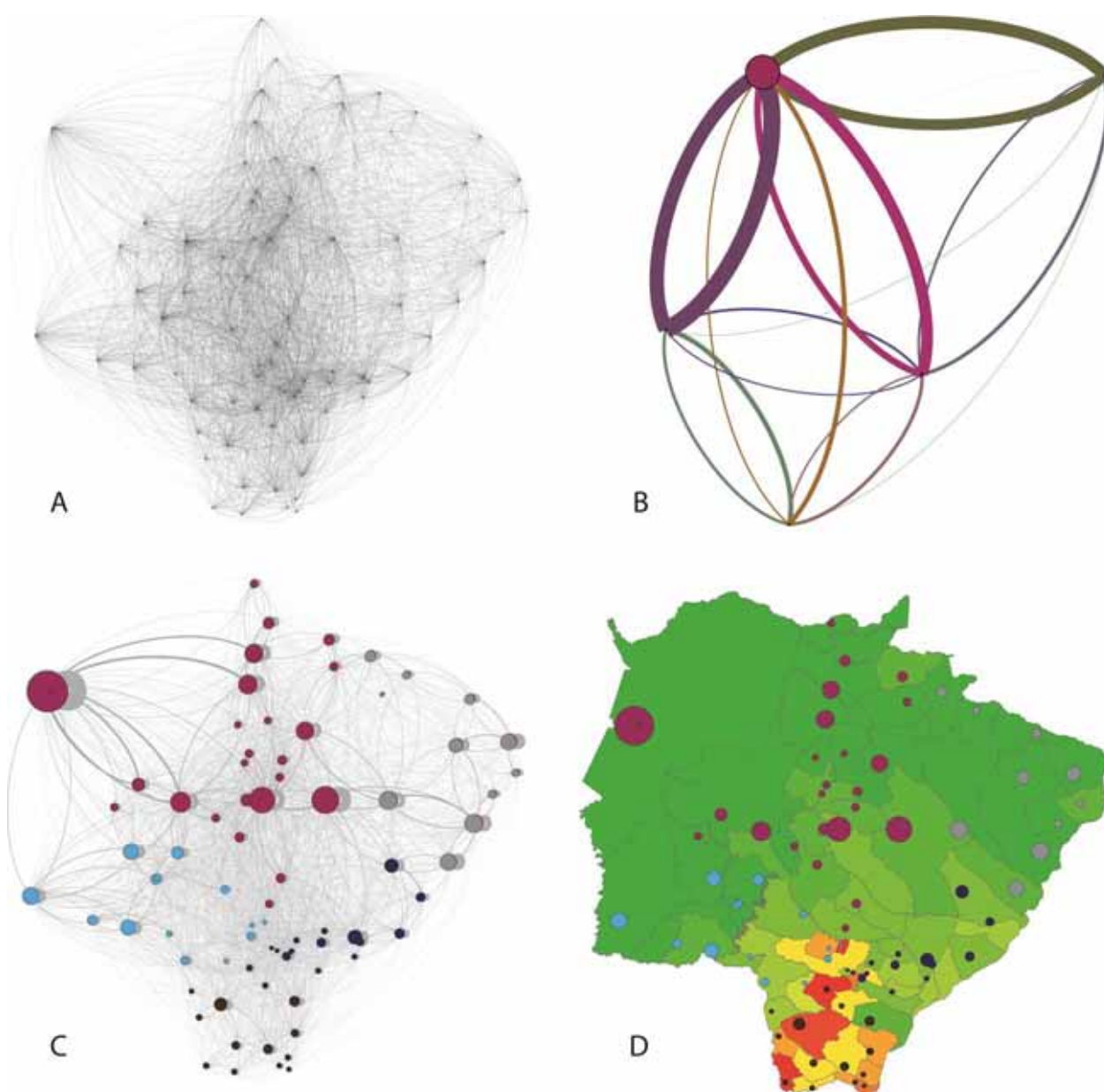


FIGURE 2 – Cattle movement network in Mato Grosso do Sul state. Brazil (A); nodes clustered by the Infomap algorithm (B); graphical representation of the municipalities cluster according to the degree of relationship (nodes of the same color), number of animals moved between two nodes (edge thickness) and weighted degree of income and outcome (node diameter) (C); composite graph presenting the network of animal movement plotted against the heat map of bovine cysticercosis for the year of 2012 (D).

4 Discussion

Cattle movement network and cysticercosis incidence heat map was constructed based on data from a Brazilian livestock producer state in order to aid the planning and implementation of cysticercosis 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 at the same farm or in two or three different ones, requiring cattle movement, sometimes between geographically distant regions.

With respect to the cattle movement network in Mato Grosso do Sul state we observed that the municipalities tend to trade more frequently among themselves and their closest neighbors, probably due to economic interests and poor transportation infrastructure (specially roads). An intense cattle movement in the Central and Northwestern regions of the state was observed possibly due to the fact that these regions are the key ones for cattle fattening (either on pasture or feedlots) as well as for beef industrialization in the state, particularly industrial plants licensed to export meat (IBGE, 2013). This observation is also supported by the fact that 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.

In the present study the occurrence of bovine cysticercosis identified at slaughterhouses 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 with official veterinary inspection, resulted in low incidence (1%) of bovine cysticercosis (SCHENK et al., 1982). Latter, Carmo et al. (1997) observed 1.8% of occurrence in steers slaughtered at one of the state municipalities. Another study conducted on steers from the Mato Grosso do Sul state between 1996 to 2000 resulted in 4.7% positivity (MARQUES et al., 2008). From 2003 to 2010, Tavares et al. (2012) observed prevalence ranging from 0.0045% to 6.3% among all municipalities of the state. Authors also observed that highest incidence occurred at the municipalities that bordered Paraguay, in particular Amambaí 6.03%, Iguatemi 5.66% and Naviraí 4.68%. This higher incidence 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 an increase of agriculture activities that demand higher number of hand labor force along the years.

Another fact that may have influenced this higher incidence is that the Southern region of the state presents the highest density of indigenous villages and settlement of “landless workers” where properties lack adequate sewage disposal system and water treatment and are near the urban area, worsening the risk of transmission. Aragão et al. (2010) evaluated steers from two indigenous villages located in the peripheral area of a Southern city (Dourados) and observed bovine cysticercosis incidence of 18.75%.

The observed results from the cattle network movement and mapping analysis suggest that the Southern region of the State would be a priority target for implementing cysticercosis control measures.

5 Conclusion

The use of relational and geospatial data to construct a cattle network movement and a cysticercosis heat map allowed an overview of the bovine cysticercosis occurrence in the state of Mato Grosso do Sul, highlighting characteristics of each region as well as providing support for planning the control actions to be implemented. Notification and traceability would be of great value to the control of bovine cysticercosis.

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

LONGITUDINAL STUDY FOR CONTROLLING BOVINE CYSTICERCOSIS ON A BEEF CATTLE FARM *

ABSTRACT

Bovine cysticercosis is a problem distributed worldwide that results in economic losses mainly due to the refrigeration and condemnation of infected carcasses. One of the difficulties in controlling this zoonosis in Brazil is the fact that bovine are acquired from multiple farms and identification of the cattle farm of origin is not always possible. We aimed to construct an animal movement network for a beef cattle farm where cysticercosis occurred and modifications were applied to the existing health management and the cattle treatment protocol. Concomitantly, basic sanitary educational activities were implemented. Eight farms that had commercial trades were identified by the animal movement network and characterized as the main contributors to the occurrence of cysticercosis in the farm studied. The use of traceability information, together with changes in health management and the sanitarian actions adopted resulted in a gradual decrease in cysticercosis prevalence 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 toward controlling bovine cysticercosis, to minimizing economic losses and to preventing human taeniasis.

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

*Artigo redigido segundo normas do periódico Veterinary Parasitology (Anexo 1).

1 Introduction

Bovine cysticercosis occurs by the accidental intake of *Taenia saginata* eggs that are present in the environment due to improper disposal of infected human feces. Carcass condemnation aims to prevent human infection. In the beef cattle breeding system in Brazil, cows are acquired from multiple farms, which implies that control of the disease must involve fighting infection in the farm of origin (Peixoto et al., 2012). This disease could be controlled through traceability since the process permits the gathering data concerning the origin of a specific animal from the moment the individual is identified to the entire movement of the animal's life.

This study aimed to elaborate and execute a strategy to identify farms registering the occurrence of bovine cysticercosis by assessing animal movements of a beef cattle farm that acquires bovine from multiple sources. Control measures to reduce occurrence were applied.

The traceability process consists in tracing back information of an animal product through the supply chain by means of recorded identification, which is used to include longitudinal data of an animal in a secure database. In Brazil, bovine and bubaline traceability follows specific legislation and is coordinated and performed by the Ministry of Agriculture, Livestock and Food 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, in contrast to 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, since there is no differential payment for traced bovine, the adoption of this system is restricted to a few cattle breeders (Lopes et al., 2008).

Currently, Animal Movement Permits (AMPs) are one of the main tools for traceability in Brazil. However, AMPs do not allow individual traceability, since the information they contain concerns 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).

2 Material and methods

2.1 Studied area

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

Between 2011 and 2013, our group monitored a beef cattle farm located in the Três Lagoas municipality (S 20° 5' 20.98" W 052° 7' 07.49"), which focuses on the confinement of male steers in feedlots. The mean time the steers remain at the farm is 30 months, before entering feedlots. These animals are acquired from multiple sources and are mainly composed of crossbred dairy steers, aged between 4 and 36 months-old. They are maintained in a grazing system with brachiaria pasture, divided into lots of 200 bovine until they reach 400 kilograms (kg), and then they 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 the bovine are provided with is captured from a farm water spring and pumped to a central tank from where it is distributed to the pastures and feedlots. Only three partitions permit direct access to the river and natural ponds.

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

2.2 Bovine movements networks

Based on the data obtained from the farm and animal supplier Animal Movement Permits (AMP), an animal movement network was constructed according to Grisi et al. (2013), using the open source software Gephi 0.8.2 (Gephi 0.8.2 beta, 2009).

2.3 Bovine cysticercosis treatment

Until 2010, cattle deworming on the farm studied was performed by the subcutaneous application of 17% albendazol sulfoxide, Ricobendazole® (7.5 mg/Kg), 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 15% albendazol sulfoxide, Agebendazol® (7.5 mg/kg), 60 and 30 days before entering the feedlot, on the day they enter the feedlot, and 30 days later. All the bovine were slaughtered only 40 days after the last application, following the manufacturer's recommendations.

2.4 Sanitary education

Sanitary education activities were conducted in the farm, involving the provision of information concerning personal hygiene and eating habits, presented in the form of talks.

2.5 Sanitary inspection

Animal slaughters were performed in slaughterhouses under the 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 period studied was assessed by the Two Sample Binomial Proportions test, using the *BioEstat* software, version 5.3 (Mamirauá/Brasil) (Ayres et al., 2007).

3 Results

The bovine movement network of the farm under study involved 101 municipalities and 7 clusters, showing regions with preferential trades (Figure 1). The property presenting the highest animal movements is located in the municipality of Três Lagoas, MS (30.7%), where the study was conducted. This extensive 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 27.9% of the total number of purchased animals (Table 1). Other municipalities with intense movement were located in the states of São Paulo (SP), Goiás (GO) and Mato Grosso do Sul (MS).

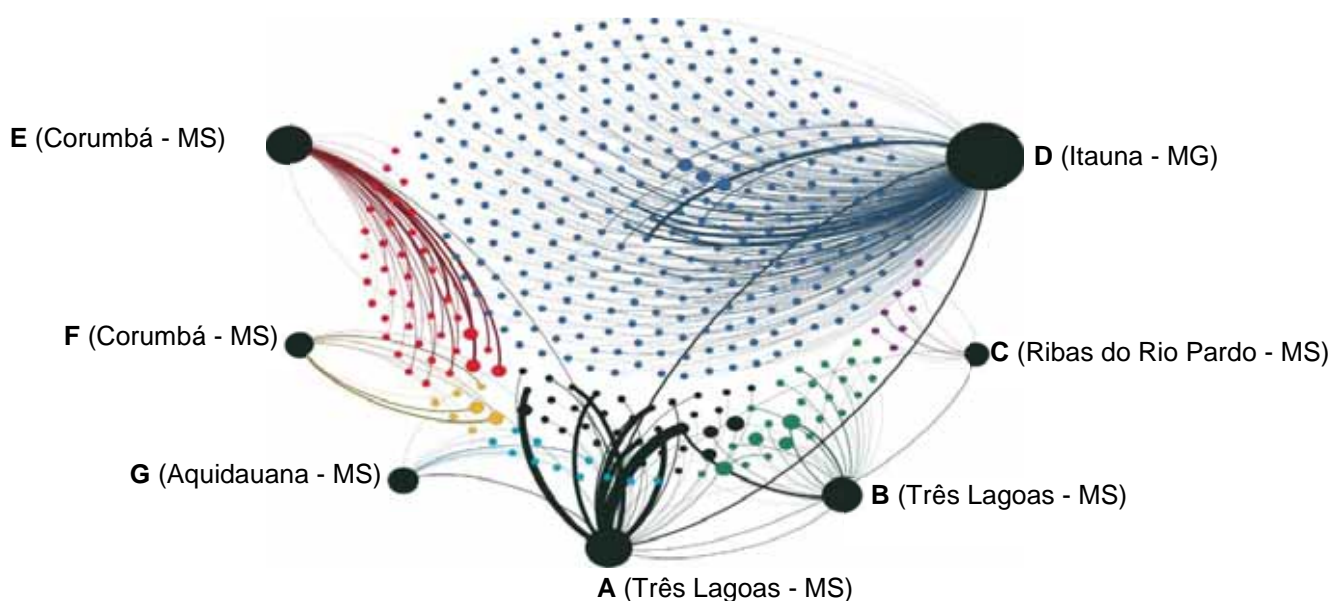


FIGURE 1. Animal movement network of a beef cattle farm (A) according to the data obtained from the Animal Movement Permits from 2010 to 2012. Each node represents a farm, its diameter indicates the number of bovine that entered or left the farm and, each edge represents the number of bovine moved between two nodes. Black nodes maintain a relationship with the farm under study (A) and clusters are indicated by colors. The letters indicate the municipality where the farm with the largest number of animals moved is located.

TABLE 1. Number of steers (n) and relative percentage (%) that entered the farm studied from 2010 to 2012. according to the municipality of origin.

Municipality	Year							
	2010		2011		2012		Total	
	n	%	n	%	n	%	n	%
Três Lagoas MS	38	1.5	518	25.7	1400	73.3	1956	30.4
Itaúna MG	1350	54.1	110	5.5	0	0	1460	22.7
Presidente Epitácio SP	0	0	1082	53.6	22	1.2	1104	17.2
Inocência MS	819	32.8	0	0	259	13.6	1078	16.8
Cassilândia MS	0	0	240	11.9	0	0	240	3.7
Coxim MS	0	0	0	0	216	11.3	216	3.4
Corumbá MS	155	6.2	0	0	0	0	155	2.4
Ribas do Rio Pardo MS	84	3.4	33	1.6	0	0	117	1.8
Aquidauana MS	50	2	0	0	0	0	50	0.8
Holambra SP	0	0	20	1.0	0	0	20	0.3
Amparo SP	0	0	12	0.6	5	0.3	17	0.3
Rio Brilhante MS	0	0	1	0.1	4	0.2	5	0.1
Pontes Gestal SP	0	0	0	0	3	0.2	3	0.1
Aporé GO	0	0	0	0	2	0.1	2	0.0
Bauru SP	0	0	2	0.1	0	0	2	0.0
Total	2496	100	2018	100	1911	100	6425	100.0

A total of 4.967 cows from the farm studied were slaughtered between 2010 and 2013. A decrease in the occurrence of live cysticercosis cysts and a significant difference ($p \leq 0.0035$) in the percentage of observed live cysts between the years studied was observed (Table 2).

TABLE 2. 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 ($p \leq 0.05$)

Three talks were given to all farm employees in the period studied, as well as seventeen meetings and nineteen practical talks concerning bovine deworming and freezing meat from slaughtered animals that was intended for consumption on the farm.

4 Discussion

The prevalence of cysticercosis at the farm studied at the onset of the study (2010) was 25.0%, which subsequently decreased to 3.7% in 2011, 1.8% in 2012 and 0% in 2013 after we began adequate deworming, together with additional control measures, particularly the strategy of avoiding commercial trades with one farm with a greater risk of infection (Figure 1D). The initial prevalence is similar to that reported by Souza et al. (2007) in the State of Paraná, and is probably because most of the slaughtered bovine were also not properly treated. Schenk et al. (1982) reported a 1% prevalence of bovine cysticercosis in the State of Mato Grosso do Sul between 1974 and 1979; Carmo et al. (1997) determined 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; in a more recent study, Tavares et al. (2012) observed a range of 0.0045% to 6.3% for different municipalities in the same state. In

this study, prevalence on this farm achieved percentages even lower than the mean prevalence reported by the aforementioned authors.

The use of 15% albendazol sulfoxide contributed for this successful control, as previously reported Biondi et al. (1999) following the introduction of chemotherapy in a feedlot farm, where the initial occurrence of bovine cysticercosis was 37.5%, which then decreased to 4%, 1% and 0% after three treatments using 17% albendazol sulfoxide.

Data obtained from a beef cattle farm together with the information registered on the Animal Movement Permits (AMPs) concerning 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 bovine acquired in 2012 (data not shown), was between 25 and 36 months-old, indicating that these animals stayed for a shorter period of time on the farm, which suggests that they were already infected before entering the property. Thus, besides bovine treatment and sanitary educational measures, the use of the cattle movement network allowed us to identify farms with putative risk that maintained commercial trades with the one studied, such that by avoiding purchasing animals from one of these farms, the occurrence of cysticercosis gradually diminished.

The main objective of the traceability system is to individually identify, register and monitor all cattle born in Brazil (Brasil, 2002). However, the system based on lots of animals currently used in Brazil interferes with the individualized identification of animals or beef products (Rocha et al., 2002).

5 Conclusions

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

This study reinforces the importance of individual traceability as a tool for the efficient control and prevention of bovine cysticercosis.

Conflict of interest statement

The authors declare there are no conflicts of interest of a financial or personal nature.

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ANEXO 1

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