











Taeniasis-cysticercosis complex in the agrarian reform rural settlements, Brazil¹

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ABSTRACT.- Acevedo-Nieto E.C., Pinto P.S.A., Silva L.F., Guimarães-Peixoto R.P.M., Santos T.O., Duarte C.T.D. & Bevilacqua P.D. 2022. **Taeniasis-cysticercosis complex in the agrarian reform rural settlements, Brazil.** *Pesquisa Veterinária Brasileira* 42:e07028, 2022. Laboratório de Inspeção de Produtos de Origem Animal, Setor de Medicina Veterinária Preventiva, Departamento de Veterinária, Universidade Federal de Viçosa, Av. PH Rolfs s/n, Viçosa, MG 36570-900, Brazil. E-mail: ecanieto@gmail.com

Thousands of families live in agrarian reform rural settlements, these existing in Brazil since the 1980s. Factors such as agglomerations of families living in the same environment and the production of domestic animals can promote the transmission and maintenance of zoonosis in these areas. The epidemiology and geographic distribution of zoonotic diseases in settlement communities need to be highlighted. The present study aimed to investigate the prevalence, risk factors and spatial distribution of the teniasis-cysticercosis complex in the agrarian reform rural settlements in the state of Minas Gerais. A total of 497 family farming properties, distributed in 52 settlements, were randomly selected and sampled. Biological samples of humans, cattle and pigs were collected and processed. Survey questionnaires were applied in each family farming property to collect data on animal production as well as sanitary, hygienic and social conditions of each family. Human fecal samples were analyzed for detection of teniasis infection, while animal blood samples were collected and subjected to serological testing to detect the cysticercosis infection. A total of three (0.35%) positive cases of human teniasis were identified, 64 (4.2%) of bovine cysticercosis and 17 (3.3%) of swine cysticercosis. Prevalence per family farming unit was 0.6% (3/497) of taeniasis through fecal test, 5.8% (17/294) for swine cysticercosis and 11.1% (52/469) for bovine cysticercosis. The spatial profile for human teniasis and swine cysticercosis were clustered in two different regions, while bovine cysticercosis showed a dispersed geographical distribution. Two risk factors were associated with the occurrence of bovine cysticercosis: stream as source of water ($p=0.009$) and the environment as destination of sewage ($p=0.031$), while burning of garbage was shown to be a significant protective factor ($p<0.001$). Risk factor for swine cysticercosis was associated with the presence of free range pigs ($p=0.008$) and the environment as the destination of sewage ($p\leq 0.024$). The low number of positive human taeniasis did not allow statistical analysis. These zoonotic diseases represent a significant risk to public health because of their occurrence in livestock which are produced for both beef consumption and for commercialization. Significant endemic areas in the state of Minas Gerais have been determined in this study, and these discoveries suggest the importance of further investment in public health education about teniasis-cysticercosis transmission, the improvement of sanitary facilities for the settlements such as source and treatment of

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water and adequate destination of sewage. Integrated actions between the human, animal and environmental health sectors, at local and regional levels are needed, aiming at the adoption of effective public policies for the control and eradication of the teniasis-cysticercosis complex where the disease occurs.

INDEX TERMS: Epidemiology, zoonosis, agrarian reform, taeniasis-cysticercosis, one health, Brazil.

RESUMO.- [Complexo teníase-cisticercose em assentamentos da reforma agrária, Brasil.]

Milhares de famílias vivem nos assentamentos da reforma agrária, criados no Brasil desde a década de 1980. Fatores como aglomerações de famílias convivendo no mesmo ambiente de produção de animais domésticos podem favorecer a transmissão e manutenção de zoonoses nessas áreas. A epidemiologia e distribuição geográfica das doenças zoonóticas nas comunidades assentadas precisam ser destacadas. Neste sentido, o presente estudo objetivou investigar a prevalência, fatores de risco e distribuição espacial do complexo teníase-cisticercose nos assentamentos rurais da reforma agrária no estado de Minas Gerais. Um total de 497 propriedades da agricultura familiar, distribuídas em 52 assentamentos, foram selecionadas e amostradas aleatoriamente. Amostras biológicas de humanos, bovinos e suínos foram coletadas e processadas. Questionários epidemiológicos foram aplicados em cada propriedade para a coleta de dados sobre a produção animal, condições sanitárias, higiênicas e sociais de cada família. Amostras fecais humanas foram analisadas para detecção de infecção por teníase, e amostras de sangue de animais foram coletadas e submetidas a testes sorológicos para detecção de infecção por cisticercose. Foram encontrados três (0,35%) casos positivos para teníase humana, 64 (4,2%) para cisticercose bovina e 17 (3,3%) para cisticercose suína. A prevalência por unidade de agricultura familiar foi de 0,6% (3/497) para teníase por exame fecal, 5,8% (17/294) para cisticercose suína e 11,1% (52/469) para cisticercose bovina. O perfil espacial da teníase humana e da cisticercose suína agrupou-se em duas regiões distintas, enquanto a cisticercose bovina apresentou distribuição geográfica dispersa. Dois fatores de risco estiveram associados à ocorrência de cisticercose bovina: riacho como fonte de água ($p=0,009$) e meio ambiente como destino de esgoto ($p=0,031$), enquanto a queima de lixo mostrou-se um fator de proteção significativo ($p<0,001$). O fator de risco para cisticercose suína foi associado à presença de suínos caipira ($p=0,008$) e ao meio ambiente como destino do esgoto ($p\leq 0,024$). Estas doenças zoonóticas representam um risco significativo para a saúde pública devido à sua ocorrência em rebanhos que são produzidos tanto para consumo de carne quanto para comercialização. Neste estudo os assentamentos analisados se configuram em áreas endêmicas no estado de Minas Gerais, e esses achados sugerem a importância de maiores investimentos na educação em saúde pública, melhoria das instalações sanitárias dos assentamentos como fonte e tratamento de água e destinação adequada de esgoto. São necessárias ações integradas entre os setores de saúde humana, animal e ambiental, em âmbito local e regional, visando a adoção de políticas públicas efetivas de controle e erradicação do complexo teníase-cisticercose onde estiver presente.

TERMOS DE INDEXAÇÃO: Epidemiologia, zoonose, reforma agrária, teníase-cisticercose, saúde única, Brasil.

INTRODUCTION

The Agrarian Reform is a legal program in Brazil that allows the government to obtain an unproductive large farm to create a rural settlement community composed of several farming families. This area aims to provide housing conditions and household production, ensuring food security for people that were previously under dietary and social risk. They are created by the “Instituto Nacional de Colonização e Reforma Agrária” (National Institute of Colonization and Agrarian Reform - INCRA). Thousands of families have been benefited from this program, but due to bureaucracy and consequent delays in the process of regularization and supporting the families, such as the access of funds for production and construction, many families live under inadequate sanitary conditions, which added to the agglomeration of families, leads to the occurrence of zoonotic diseases. Teniasis-cysticercosis complex (TC) is a zoonotic disease associated with humans, animals and the environment, and it is caused by two different helminths. *Taenia saginata* and *Taenia solium*, cattle and pigs are its intermediate hosts, respectively, and humans are the definitive host for both parasite species (CDC 2021). Infected animals contain the larval stage of the parasite, which appears inside a cyst in muscle tissue, a disease called cysticercosis (Braae et al. 2018, Garcia et al. 2020). Humans carry the adult form of both parasites known as tapeworm, and they can also act as intermediate hosts for *T. solium*. The larvae most often grow within the nervous system and cause neurocysticercosis (NCC), which is the most important parasitic disease affecting the neurological system. It is estimated that about 30% of all cases of acquired human epilepsy in endemic areas are caused by NCC (Bustus et al. 2021). *T. solium* infection is in the B list of infections of the World Organization for Animal Health (Braae et al. 2018). The prevalence of TC in Brazil is often underestimated due to the still lack of field research throughout the country, the absence of mandatory reports in almost all states, and the fact that the cases most frequently reported originated from data collected in slaughterhouses. For these reasons, the reality in Brazil is misinterpreted, as it is common the consumption of pork or beef that is not inspected and not slaughtered in a slaughterhouse.

The development of immunoassay techniques has resulted in a practical and efficient alternative for the diagnosis of animal cysticercosis. The ELISA and Western Blot tests have been applied to determine the epidemiological profile of this zoonosis (Pinto et al. 2000a, Monteiro et al. 2006, Acevedo Nieto et al. 2012, Santos et al. 2013, Acevedo-Nieto et al. 2017, Guimarães-Peixoto et al. 2020). The use of questionnaires is another important tool for identifying risk factors (Souza et al. 2013, Kusolsuk et al. 2021). Records of immunoassay tests combined with data from the questionnaires provide knowledge of the disease epidemiology, thus providing information on the most appropriate control measures. A Geographic Information System (GIS) approach is also an important tool that has been applied in epidemiological

studies for the purposes of screening and detection, analysis and decision making (Raoul et al. 2013, Rossi et al. 2016, Maia et al. 2017).

Elucidation of the epidemiology of TC in settlements communities can provide robust evidence to justify and implement public policies to control and also eradicate this important zoonosis that is still present in Brazil. For that, the present survey was conducted with the aim of establishing the prevalence and spatial distribution, and identifying risk factors associated with the transmission of human tapeworm and animal cysticercosis infections in rural settlements communities in the state of Minas Gerais, Brazil.

MATERIALS AND METHODS

Study area. This study was developed in settlements in the state of Minas Gerais, which is located in the Southeast of Brazil. It is the fourth largest state in Brazil, with 586.5km², 853 cities and a population of 20.5 million inhabitants. There are 266 settlements in Minas Gerais, with 13.890 farming family unit's (FF) where approximately a total of 55,500 inhabitants' lives.

Research ethics. The study was approved by the Animal Research Ethics Committee (CEUA), and by the Human Research Ethics Committee (CEP) from the "Universidade Federal de Viçosa" (UFV). Application of the epidemiological questionnaires and sample collection were performed under the written consent of the resident in charge of each FF sampled, after the study purpose had been explained to the owners, there was the option of refusing participation.

Study design and sampling. A cross-sectional epidemiological study was conducted under cluster sampling design. The number FF to be sampled was calculated based on the following parameters: estimated prevalence of swine cysticercosis 2.5% (obtained in a previous pilot study conducted in the municipality of Tumiritinga in 2010), confidence interval of 99%, significance level of 0.05 and acceptable error of 2%. Based on these preliminary values, the resulting sample size was 497 FF. It was calculated using the Software EpiInfo version 7.1.4 (CDC 2012). To calculate the number of individuals to be sampled (human, swine or bovine), the average of four was considered, one and four individuals per FF, respectively. In this way, the minimum percentages required for sampling were 26% of humans, 28% of pigs and 22% of cattle, of the existing total of each one. The same proportion of samples was established per region, and the state was divided into seven regions (Jequitinhonha-Mucuri, Vale do Rio Doce, North, Triângulo Mineiro, Northwest, Alto Paranaíba and South Central). A total of 20% of the human rural settlements were sampled per region, and 30% of FF were randomly sampled in each one of them (Fig.1). Table 1 lists the number of samples obtained.

Animal sampling. In each FF blood samples were collected from pigs and cattle. Samples were collected from pigs over three months old in order to avoid false-positive results due to passive immunity transferred to the piglets. Blood samples were taken from the orbital plexus of the pigs and from the jugular vein of the cattle. Approximately 10ml of blood was collected from each animal. The blood was centrifuged at room temperature immediately after collection at 900G per 6 minutes to obtain the serum; then, it was frozen and stored at -20°C until processing. The pig population consisted of crossbred pigs and pigs of a non-defined breed raised in rustic conditions. The cattle population consisted of crossbred cattle used for beef and dairy purposes.

Human sampling. Stool samples were collected from each member of the FF. The containers were left for collection with the

respondent (usually the owner) after the interviews. The correct procedure was explained to all present and the samples were collected the next day. Each sample was measured in a 50ml container with 25ml of preservative merthiolate-iodine formaldehyde solution (MIF, Renylab®) to allow transport and subsequent parasitological analysis. The presence of helminth eggs in the stool was examined microscopically using the Hoffman-Pons-Janer (HPJ) technique. Presence of a *Taenia* spp. egg on a slide was recorded as the FF being positive for teniasis. The analyses were performed at the "Laboratório de Parasitologia Veterinária" (Parasitology Laboratory) of the "Departamento de Veterinária" (Veterinary Department) at the UFV, Minas Gerais.

Laboratory analysis. The indirect ELISA test was used for screening animal samples. Positive cases were subjected to a Western Blot to

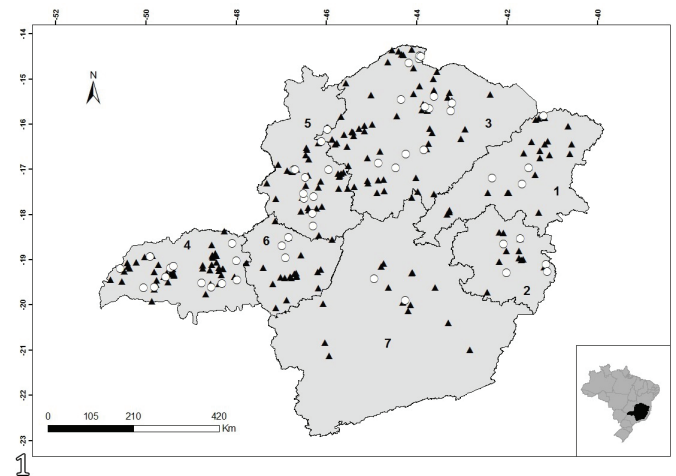


Fig.1. Representation of human rural settlements in the state of Minas Gerais, Brazil. Identification of the settlements sampled (○) and non-sampled (▲), and the division of the state into seven regions: Jequitinhonha-Mucuri (1), Vale do Rio Doce (2), North (3), Triângulo Mineiro (4), Northwest (5), Alto Paranaíba (6) and Central South (7).

Table 1. Total number of samples collected by region of settlements in the state of Minas Gerais, Brazil

Region	Settlement	FF*	Sampled (%)			
			Human	Bovine	Swine	Survey
1 - Jequi-Mucuri	5	35	62 (58)	106 (73.6)	35 (77.7)	35
2 - Vale do Rio Doce	4	32	59 (57)	100 (78.7)	35 (67.3)	32
3 - North	14	112	211 (58)	333 (68.6)	120 (73.6)	112
4 - Triângulo Mineiro	13	121	180 (42)	374 (59.5)	124 (58.5)	121
5 - Northwest	9	122	217 (49)	384 (53.7)	122 (44.2)	122
6 - Alto Paranaíba	5	52	88 (46)	165 (55)	58 (54.7)	52
7 - South Central	3	23	38 (41)	71 (60.6)	24 (51.1)	23
TOTAL	53 (20)	497 (30)	855 (49)	1533 (60.9)	518 (57.5)	497 (30)

(%) Percentages of samples collected per region; * FF = family farming units.

provide a conclusive diagnosis. The prevalence was estimated by the conclusive result from the Western Blot test. For the serological tests, the heterologous total antigen of *Taenia crassiceps* was used, according to the following methodology established by Pinto et al. (2000b, 2001).

Assessment of risk factors. An epidemiological survey was conducted using a previously tested structured questionnaire containing closed and open-ended questions. The whole questionnaire was administered by the same interviewer to each FF owner. The questionnaire allowed the assessment of potential risks or protective factors associated with the occurrence of taeniasis and cysticercosis. Information was collected on sanitary facilities, family habits, source of meat and water, breeding system, animal management and knowledge about the taeniasis-cysticercosis complex. In addition to the responses of the owners, the conditions of latrines and bathrooms of each FF were directly observed by the researcher. The interview was conducted informally before blood samples were collected from the animals. Geographic coordinates of each FF were obtained using a Global Positioning System (GPS) receiver (eTrex LegendH Cx, Garmin) to allow mapping and spatial analysis.

Statistical analysis. Data were analyzed by descriptive and logistic regression performed on Stata® 13.1 software. Multivariate logistic regression analyses by backward stepwise selection were performed to identify the significantly explanatory variables associated with human taeniasis, swine and bovine cysticercosis, separately. In the first step, binary bivariate logistic regression was processed to select the significant variables whose results were $p < 0.20$. These variables were included in a multivariate logistic regression model for the subsequent steps, where each non-significant covariates ($p > 0.05$) were removed from the model stage to assess confounding effects and obtain the adjusted model.

Spatial analysis. The G-statistic (Getis & Ord 1992) was used to determine the spatial correlation of the attributes of the physical environment that influence the occurrence of diseases. The local G-statistic was estimated from groups of neighbors using the critical distance of each area. The critical distance was formed from a proximity matrix. The null hypothesis for the G-statistics states that there is no spatial clustering of values, and the z-index is used for the hypothesis testing. These analyses as well as the maps of clustering of the variable values according to the z statistic were

conducted in ArcGIS 10.1. The maps were made to allow visualization of the spatial distribution separately for each disease (Fig.2 and 3).

RESULTS

A total of 497 (30%) family farming units (FF) was sampled in 53 (20%) human rural settlements throughout the state. From this total, 49% of the human, 60.9% of the bovine and 57.5% of the swine population were sampled as described in Table 1. The average number of individuals per FF was 1.7 ± 0.8 humans, 1.0 ± 1.2 pigs and 3.1 ± 1.9 cattle. Table 2 shows the prevalence for each species and for FF discriminated per region, while the Table 3 shows the analysis of potential risk factors associated with the occurrence of swine and bovine cysticercosis.

Human taeniasis

Prevalence of 0.3% (3/855) was obtained by microscopy exam. Concerning FF, 0.6% (3/497) was positive for tapeworm carriers by microscopy exam. Tapeworm carriers were found in the North and Northwest regions by microscopy exam. Because of the low number of positive cases registered through diagnostic exams, regression analysis could not be included for risk factors.

Swine cysticercosis

The prevalence for swine cysticercosis was 3.3% (17/518), and 5.8% (17/294) of the FF were positives for them. In each FF, only one positive case was diagnosed. The disease was recorded in 4 out of the 7 study regions and endemic levels were registered at Vale do Rio Doce (8.6%) and Triângulo Mineiro (6.5%) regions. The presence of free range pigs ($p = 0.008$) and outdoor human waste disposal ($p < 0.024$) were correlated significantly with swine cysticercosis. The type of garbage treatment (burned) was a protective factor for swine cysticercosis ($p < 0.001$).

Bovine cysticercosis

Prevalence of 4.2% (64/1533) was found for bovine cysticercosis by the serological test, and 11.1% (52/469) of the

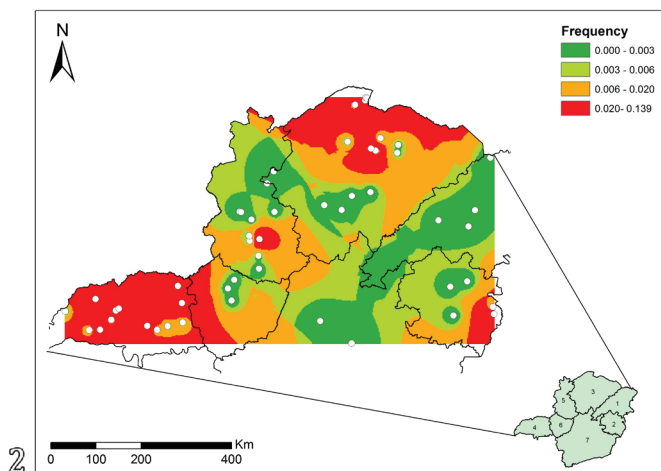


Fig.2. Classification of the diseases by frequency (positive case/total population) as a result obtained by Getis Ord Gi, for swine cysticercosis based on serological tests.

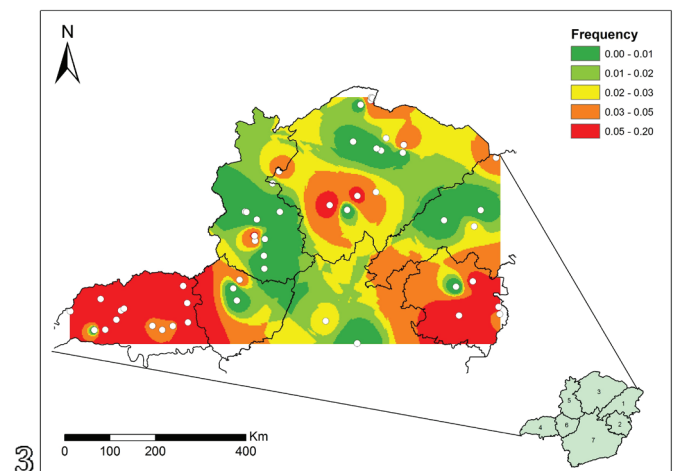


Fig.3. Classification of the diseases by frequency (positive case/total population) as a result obtained by Getis Ord Gi, for bovine cysticercosis based on serological tests.

FPU were positive, ranging between one and three positive cases per property. There were cases of bovine cysticercosis in all regions, and the significant risk factors were streams as a water source ($p=0.009$) and outdoor human waste disposal ($p=0.031$). The type of garbage treatment was a protective factor for cysticercosis in cattle as well in humans and pigs.

Descriptive analysis of social, economic and sanitary conditions

From a total of 497 FF, 294 (59.2%) had pigs and 469 (94.4%) had cattle. As for the animal breeding system, 178 (60.5%) raised pigs exclusively in pens and 39.5% raised pigs at large. In all of the FF cattle were raised at free range. In terms of animals raised for consumption, pigs were raised for consumption in 100% of the FF and in 48.3% (N=142) they were also raised for sale. In 74.5% of the FF (N=219), the owner sold pork in the neighborhood, and 25.5% (N=75) of them sold pork to the local market or other places in the municipality. Only 2.8% (13/469) of the FF raised cattle for sale while in 456 (97.2%), the main purpose was milk production, but also sporadic consumption and sale of oxen and old cows. Regarding the destination of the meat, 28 FF sold to their own neighbors and 94% (N=441) sold to the local market. Vegetables were produced in 73.4% (365/497) of the FF, for two purposes: self-consumption and commercialization of surplus production in the town market.

It was observed that 27% (134/497) of the FF do not have a bathroom and human feces are carried outdoors/directly into streams nearby. The northern region showed the largest number of households with disposal of human waste outdoors 45% (51/112), followed by the Vale do Rio Doce regions 28.1% (9/32) and Triângulo Mineiro 28% (34/121).

Concerning garbage disposal, burn is a common practice in 82.9% (412/497) of the FF and in 17.1% (85/497) of them, it is disposed of outdoors without any treatment. The Northern region showed the highest proportion of outdoor destinations of garbage, 25% (28/112).

Concerning the water source, for 48.9% (243/497) of the FF comes from surface features such as streams and springs and for 51.1% (254/497) it comes from an artesian well. Only 21.1% (105/497) of the FF treat water before human consumption. There was a high frequency of untreated water for human consumption 78.9% (392/497), ranging from 73% to 91% in the Northwest and the Northern regions.

Regarding the source of water for animal consumption, 67.8% (337/497) comes from surface water and 32.2% (160/497) from artesian wells.

Regarding knowledge of cysticercosis, 30.4% (N=151) were aware of what it is, while 69.7% reported not knowing cysticercosis. Only 18.9% (N=94) reported having seen cysticercosis and everyone observed it only in pork; 69.1% (N=65) of those who have seen cysticercosis reported observing it in their own settlement and 30.9% (N=29), in the municipality.

It was observed that 78.3% (389/497) of the FF had two or more of the risk factors for the taeniasis cysticercosis complex accessed in this survey.

Spatial analysis

Spatial autocorrelation accessed the degree of similarity between neighboring points and the occurrence of positive cases. The pattern of distribution for swine cysticercosis showed a clustered pattern of distribution (G-statistic=0.24, $p=0.004$) (Fig.2). Bovine cysticercosis was dispersal throughout the state (G-statistics=0.14, $p=0.374$) (Fig.3).

DISCUSSION

This study is an important community-based survey in Brazilian agrarian reform rural settlements that shows the taeniasis-cysticercosis complex (TC), a food-borne zoonotic disease, in several settlements communities. The low number of positive cases of taeniasis recorded did not allow the analysis of risk factors, however, the presence of human carriers in all regions is evident due to positive findings in animals. The potential source of stream contamination was household sewage destination because a large number of family farming units (FF; 134) did not have a cesspit or adequate facilities for human waste disposal. In these households, sewage is taken outdoors or directly to streams, leading to animal infection through the consumption of contaminated water with parasites and eggs. All of the seven regions had FF with outdoor human waste disposal and the highest percentage was found in North (45.5%), Vale do Rio Doce (28.1%) and Triângulo Mineiro (28%). These same regions had the highest prevalence of swine and bovine cysticercosis.

The prevalence for swine cysticercosis was 3.3%(17/518) and the free range pigs practices was observed in 39.5%

Table 2. Prevalence of human taeniasis, swine and bovine cysticercosis, and frequency of positive family farming units (FF) discriminated per region in the state of Minas Gerais, Brazil

Region	Prevalence (positive/total)	% positive FF (positive FF/total FF)	Region	Prevalence (positive/total)	% positive FF (positive FF/total FF)	Region
	Human TO*	Bovine C**		Swine C**	Human TO*	
1 - Jequi-Mucuri	0 (0/62)	1.9 (2/106)	0 (0/35)	0	15.6 (5)	3.1 (1)
2 - Vale do Rio Doce	0 (0/59)	7 (7/100)	8.6 (3/35)	0	5.7 (2)	0
3 - North	0.9 (2/211)	3.3 (11/333)	3.3 (4/120)	1.9 (2)	6.2 (7)	3.6 (4)
4 -Triângulo Mineiro	0 (0/180)	8.3 (31/374)	6.5 (8/124)	0	21.5 (26)	6.6 (8)
5 - Northwest	0.5 (1/217)	2.1 (8/384)	1.6 (2/122)	0.8 (1)	5.7 (7)	1.6 (2)
6 - Alto Paranaíba	0 (0/88)	1.8 (3/165)	0 (0/58)	0	5.8 (3)	0
7 - South Central	0 (0/38)	2.8 (2/71)	0 (0/24)	0	8.7 (2)	8.7 (2)
TOTAL	0.35 (3/855)	4.2 (64/1533)	3.3 (17/518)	0.6 (3/497)	11.1 (52/469)	5.8 (17/294)

* TO = taeniasis based on microscopy examination, ** C = cysticercosis.

of the FF. The practice of raising free-range pigs was more frequent than that observed in the study by Souza et al. (2013) in a rural community in Minas Gerais State, where 8.5% of the properties had free range pigs. This risk factor was the most strongly associated with swine cysticercosis (OR:8.1, $p=0.008$) because access to parasite eggs is favored, once 27% of FF lack adequate infrastructure for human fecal waste. In another study, Acevedo-Nieto et al. (2017) found, through serological tests, a higher frequency of 5.26%(13/247) for swine cysticercosis. In the same study, the most decisive risk factors for swine cysticercosis were also free range pigs (OR:17.4, $p:0.0001$) and the outdoor destination of the human faeces (OR:7.6; $p:0.012$). The coexistence of poor sanitary conditions with outdoor human waste disposal (OR:4; $p=0.040$)

and free range pigs (OR:8.1; $p=0.008$) certainly plays an important role in the dissemination of *T. solium* infection in rural agrarian reform settlements. In a study, Mwang'onde et al. (2014) demonstrated that humans' defecation in the bush is associated with swine cysticercosis, and they claim that the stools are a good source of food and immediately accessed by the animals. The lack of knowledge and information about the TC by the community settlements was also found in our study, and it calls for improvements in public health education.

Meat without inspection is still consumed in several regions of Brazil, mainly those where subsistence agriculture is a regular practice. It was found that 99% (294) of the households raising pigs slaughtered these animals at the FF. This high number of slaughtered pigs without inspection services

Table 3. Analysis of potential risk factors associated with the occurrence of swine and bovine cysticercosis. Unadjusted and adjusted models of multiple logistic regressions

Risk Factor	OR*	p<0.05	95% CI**
Swine			
Unadjusted model			
Free range pigs	13.06	0.001	2.92 -58.31
Breed pigs to eat and sell	2.04	0.171	0.73 - 5.67
Know about cysticercosis	0.51	0.180	0.19 - 1.36
Stream as source of water	2.71	0.067	0.93 - 7.90
Outdoor human waste disposal	8.15	<0.001	2.76 - 24.01
Garbage burned	0.12	<0.001	0.45 - 0.34
Recent settlement (>2005)	3.08	0.054	0.98 - 9.71
Settlement - large area	0.25	0.093	0.53 - 1.25
Adjusted model			
Free range pigs	8.10	0.008	1.73 - 37.82
Outdoor human waste disposal	4	0.024	1.20 - 13.34
Garbage burned***	0.31	<0.001	0.09 - 0.99
Bovine			
Unadjusted model			
Cattle from other municipalities	2.41	0.021	1.14 - 5.09
Raise cattle for marketing	0.40	0.176	0.10 - 1.50
Don't know about cysticercosis	1.72	0.125	0.86 - 3.46
Stream as source of water	2.32	0.006	1.27 - 4.24
Outdoor human waste disposal	3.43	<0.001	1.90 - 6.19
Garbage burned	0.16	<0.001	0.08 - 0.29
Recent settlement (>2005)	1.62	0.113	0.89 - 2.97
Settlement - medium area	0.61	0.144	0.31 - 1.18
Settlement - large area	0.53	0.114	0.25 - 1.15
Adjusted model			
Stream as source of water	2.33	0.009	1.23 - 4.41
Outdoor human waste disposal	2.05	0.031	1.06 - 3.96
Garbage burned**	0.20	<0.001	0.10 - 0.40

* OR = odds ratio, ** CI = confidence interval, *** protective factors.

was also observed by Souza et al. (2013), who reported that 98.0% (N=47) of the farming units performed the slaughter of these animals.

Regarding bovine cysticercosis the global prevalence was 4.2% (64/1533) and the source of water for animal consumption was associated with a significant risk factor for bovine cysticercosis ($p=0.009$). Similar frequencies were found by Almeida et al (2006) 4.9% for cattle in slaughterhouses in the Triângulo Mineiro region, and 4,7% found by Duarte et al. (2016) working in rural communities in the same region. Duarte et al. (2016) detected a significant association between bovine cysticercosis and places without adequate water treatment, suggesting an important source of infection.

The results from our study support those of Almeida et al. (2006), who pointed out that bovine cysticercosis is a current public health problem in Minas Gerais, and its prevalence has occurred at higher levels when compared to swine cysticercosis. Furthermore, the high incidence of swine and bovine cysticercosis infection in the settlements of Vale do Rio Doce, North and Triângulo Mineiro regions, suggests a heavy environmental contamination by *Taenia* spp. eggs. The general findings for the Center-South region corroborate those of other studies which showed very low prevalence for TC in these regions (Acevedo Nieto et al. 2012, Santos et al, 2013).

About the spatial analysis, a dispersal pattern of distribution was shown for bovine cysticercosis, which can be explained by the commercialization of cattle and consumption of rare beef, a very common habit among Brazilians, which also corroborates the findings of Garro et al. (2015). On the other hand, the clustered distribution observed for swine cysticercosis can be explained by the self-consumption of swine production.

Concerning the agrarian reform of rural settlements, the legal process for setting up the families and releasing credits for the development of settlements is bureaucratic and time-consuming. Settled families need attention with their health. Furthermore, as they represent a significant population of family farming that provides food for the Brazilian population, the risk of the disease can affect not only the settled population but also the population that has access to food. TC represents a threat to the health of settled families and is still a neglected zoonosis, as it has long been recognized as potentially eradicable due to the availability of diagnoses and treatments, a life cycle that involves domestic animals and for not having a vector invertebrate in its biological cycle (Schantz et al. 1993).

CONCLUSIONS

The study demonstrated that the taeniasis-cysticercosis complex is present in agrarian reform settlements in all regions surveyed.

The findings highlight the importance of researching the occurrence, determinants and relationships between humans, animals and the environment for the definition of efficient control strategies.

The different distribution patterns of cysticercosis draw attention to different control measures, with local action strategies for porcine cysticercosis and broader control measures for bovine cysticercosis.

The situation of the taeniasis-cysticercosis complex in the agrarian reform settlements in the state of Minas Gerais points to the need for a multisectoral and transdisciplinary collaboration, with actions at local and State levels, for the eradication of this zoonosis in the affected areas.

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