Original Article

Spatial distribution, prevalence and epidemiological risk factors of cysticercosis in cattle from state of São Paulo, Brazil, slaughtered for human consumption

CrossMark

Gabriel Augusto Marques Rossi[a], Welber Daniel Zanetti Lopes[b,*],
Henrique Meiroz de Souza Almeida[a], Vando Edésio Soares[c], Carlos Eduardo Gamero Aguilar[a],
Ana Maria Centola Vidal[d], Luiz Francisco Prata[a], Antonio Sergio Ferraudo[a]

[a] UNESP – Univ. Estadual Paulista, Faculdade de Ciências Agrárias e Veterinárias (FCAV), Via de acesso Paulo Castellane, s/n, CEP, 14884-900, Jaboticabal, São Paulo, Brazil
[b] Instituto de Patologia Tropical e Saúde Pública, Universidade Federal de Goiás, Goiânia, GO 74605050, Brazil
[c] Universidade Brasil, Av. Hilário da Silva Passo 950, 13690-970, Descalvado, São Paulo, Brazil
[d] Universidade de São Paulo, Faculdade de Zootecnia e Engenharia de Alimentos (FZEA), Avenida Duque de Caxias Norte 225, CEP, 13635-900, Pirassununga, São Paulo, Brazil

ARTICLE INFO

ABSTRACT

This present research focused on establishing the prevalence, geospatial distribution and epidemiological risk factors for bovine cysticercosis in the state of São Paulo, Brazil, in cattle slaughtered for human comsumption. Data about the inspection of 104,180 bovine carcasses from 215 farms and from 70 municipalities were gathered between January and December of 2012. A cluster analysis was performed in order to correlate some variables: prevalence of bovine cysticercosis, total coffee harvesting area (hectares), orange producing areas (hectares) and Human Development Index. Afterwards, distribution maps were created in order to help the results interpretation. An average prevalence of 2.9% was established in the state of São Paulo during the studied period. The Administrative regions of São José do Rio Preto and Campinas had higher risk for cysticercosis (OR > 1 and 95% CI > 1). The cluster analysis showed a grouping (G1 cluster) of the variables: prevalence of bovine cysticercosis, total area of sugar cane harvested, total area of orange harvested and total area of coffee harvested. This agrroupment allows us to infer that cyticercosis cases in this region are correlated with those variables distribution. Such aspects indicate that the presence of temporary rural workers and other socioeconomic and cultural features in each region can contribute to bovine cysticercosis dissemination in some areas.

1. Introduction

Taenia saginata teniasis is a disease caused by *T. saginata* adult stage, which parasitizes human's small intestine (definitive host). Cysticercosis is the disease caused by the larval stage of the same parasite, *Cysticercus bovis*, which parasitizes muscular tissues of cattle (intermediate host) (Lopes et al., 2014).

The presence of this helminth in cattle and human is worldwide reported however, variations in prevalence are very common. In some countries like Brazil, Belgium, Holland and France this parasite is largely distributed in animals and humans (Praet, 2007; Dupuy et al. 2014; Rossi et al., 2015).

Lopes et al. (2011) stated that cyticercosis does not have clinical significance for beef and dairy cattle, once animals usually have mild

infections with the absence of clinical signs. On the other hand, those authors emphasized producers' economical losses for slaughterhouses due to carcass depreciation or total condemnation caused by the presence of cysticerci in slaughtered cattle. An anual economic loss of aproximatelly US$ 164 millions due to bovine cysticercosis is estimated in Latin America according to Schantz et al. (1994). In the state of Paraná, Brazil, Guimarães-Peixoto et al. (2012) estimated losses of aproximatelly US$ 31,500,000.00, between years 2004 and 2008, caused by carcasses condemned due to cysticercosis. Rossi et al. (2015) estimated that farmers suffered economic losses of US$ 312,194.52 due to the occurrence of cysticercosis in some Brazilian states.

Risks factors associated with cysticercosis are described in literature, such as: access of cattle to non controlled water sources, use of

* Corresponding author.
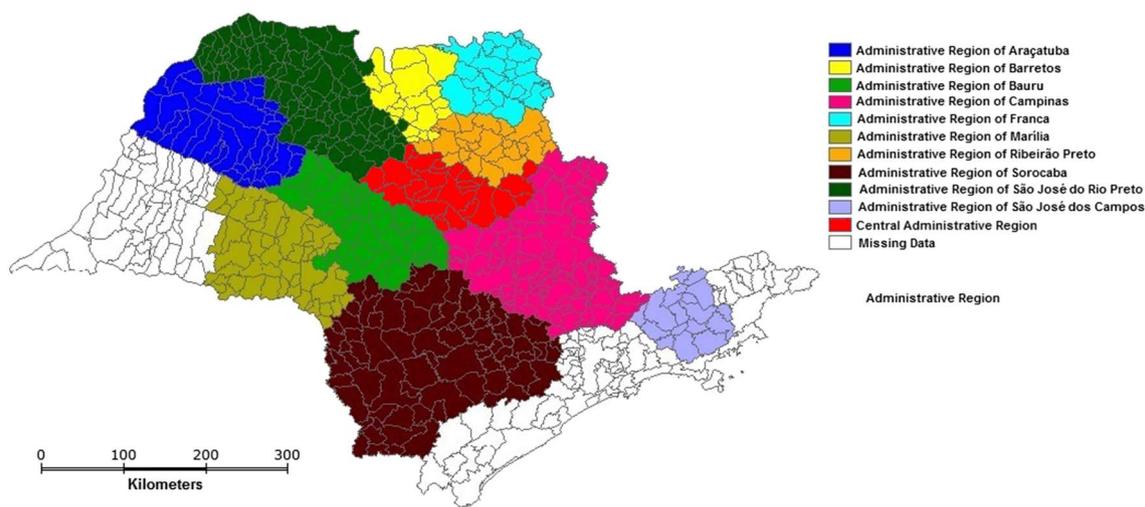E-mail address: wdzlopes@hotmail.com (W.D.Z. Lopes).

Fig. 1. Spatial distribution of the Administrative Regions that had cattle slaughtered in the slaughterhouse located in Barretos municipality, state of São Paulo, Brazil, during 2012.
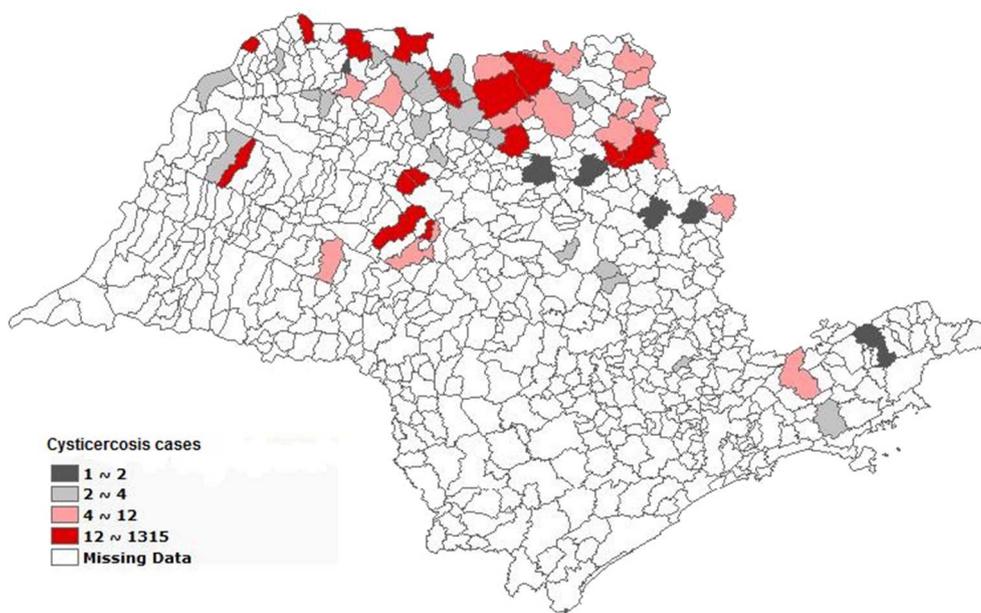

Fig. 2. Spatial distribution of bovine cysticercosis cases by municipality in the state of São Paulo, Brazil, during 2012.

urban sewage sludge on pastures, presence of recreational sites adjacent to pastures cattle feeding using contaminated food, organic farming, presence of fishermen in surroundings of farm and human population size in some areas (Kyvsgaard et al., 1991; Cabaret et al., 2002; Flütsch et al., 2008; Calvo-Artavia et al., 2013a; Calvo-Artavia et al., 2013b; Jenkins et al., 2013; Rossi et al., 2015; Rossi et al., 2016). However, a better understanding of the global epidemiology of the complex is still required (Laranjo-González et al., 2016).

This study focused on establishing the prevalence, geospatial distribution and epidemiological risk factors for cysticercosis cases in cattle slaughtered for human consumption during year 2012 in a slaughterhouse supervisioned by Federal Inspection Service in Barretos municipality, state of São Paulo, Brazil.

2. Material and methods

A total of 104,180 bovine carcasses, of both sex, with age ranging from 18 to 60 months were inspected. The animals came from 215 different farms, located in 70 municipalities in the state of São Paulo, Brazil. The bovines were slaughtered between January and December 2012 in a slaughterhouse under Federal Inspection Service (SIF) located

in the municiplaity of Barretos, state of São Paulo, Brazil.

The carcasses and viscera inspection was performed according to the Brazilian technology standard for bovines. Inspection agents are properly trained to perform *post mortem* inspection of carcasses and viscera. The routine inspection consisted on visual inspection and incisions of specific regions as heart, tongue, diaphragm, liver and masseter and pterigoyd muscles in accordance with the Federal Inspection Service from Brazilian Ministry of Agriculture, Lifestock and Food Supply (Brazilian MAPA, 1971, 1980, 1988, 1997)

If any cysticerci were detected in carcasses or viscera during inspection, the lesions were identified and half the carcasses and viscera were turned to Final Inspection Department (DIF), where they were examined by a veterinary (Federal Inspector). Later, the cysticerci were classified into viable or calcified (Biondi et al., 2000; Costa et al., 2012). Each carcass was classified according to severity of infections with *C. bovis* in low and high infections (more than one cysticerci in a area about 22 cm^2).

Prevalence was established in municipalities belonging to each Administrative Regions. The studied area is divided into 11 Administrative Regions according to the São Paulo State Agriculture and Livestok Office, as: Araçatuba, Barretos, Bauru, Campinas, Franca,

Table 1
Association analysis among Administrative Regions in state of São Paulo, Brazil, relative to apparent prevalence of bovine cysticercosis.

Administrative Region	Prevalence (%)	95% CI	Amplitude of prevalence for cysticercosis in farms	Cysticercosis Negative	Cysticercosis Positive	Total of slaughtered cattle	Representativeness of the region relative to total slaughtered cattle (%)	Odds ratio (OR)[a]	95% CI
Araçatuba	2.81	1.82 to 3.80	0.00 to 3.36	1037	30	1067	1.10	0.96	0.67–1.38
Barretos	1.67	1.58 to 1.76	0.00 to 2.30	76,213	1295	77,508	74.40	0.56	0.53–0.60
Bauru	3.64	2.63 to 4.65	2.91 to 6.00	1270	48	1318	1.26	1.25	0.94–1.68
Campinas	5.26	2.47 to 8.05	3.57 to 8.00	233	13	246	0.23	1.84	1.05–3.22
Franca	1.29	0.96 to 1.62	0.00 to 4.83	4449	58	4507	4.38	2.43	0.33–3.56
Marília	3.07	3.08 to 0.11	Not applied	126	4	130	0.12	1.05	0.39–2.85
Ribeirão Preto	2.55	1.90 to 3.19	0.00 to 8.62	2258	59	2317	2.22	1.87	0.67–1.92
Central	4.22	1.45 to 11.70	Not applied	68	3	71	0.06	1.46	0.46–4.65
São José do Rio Preto	9.01	8.65 to 9.51	0.00 to 18.68	15,328	1531	16,859	16.10	3.32	2.16–3.54
São José dos Campos	7.69	3.85 to 18.37	5.50 to 16.60	107	9	117	0.09	4.14	0.11–8.65
Sorocaba	0.00	–	Not applied	40	0	40	0.04	0.41	0.03–0.66
Total	–	–	–	101,130	3050	104,180	100%	–	–

[a] Administrative Regions with odds ratio (OR) > 1 (95% CI > 1), have higher odds of having bovine cysticercosis.

Marília, Ribeirão Preto, Central, São José do Rio Preto, São José dos Campos and Sorocaba (Fig. 1).

2.1. Data analysis

Statistical analysis was performed using the softwares Epiinfo 3.5.1 and SAEG 9.0. Homogeneity and normality was assessed through Bratlett test and Lilliefors test, respectively. In order to evaluate the risk factor associated to each region of the State, odds ratio (OR) were calculated comparing the occurrence of bovine cysticercosis of each administrative region with the total of the State of São Paulo.

Data regarding total area of sugar-cane production (hectares), coffee production (hectares), orange production (hectares), bovine population (number of animals) and the human development index (life expectancy) in the municipalities during the same period that cysticercosis data were gathered (during year 2012) were obtained through the site of the Brazilian Institute of Geography and Statistics (IBGE, 2015). Using this information, spatial distribution maps were created using Terraview® software, in order to better understand the results.

Thus, the prevalence of bovine cysticercosis and these variables were submitted to cluster analysisusing the nearest neighbor method (complete linkage) and metric Euclidean distance, using STATISTICA software 10th version, Statsoft®, Inc. (2011). The variable bovine population was not submitted to cluster analysis.

3. Results

104,180 carcasses from animals reared in 70 municipalities in the state of São Paulo (Fig. 2) were inspected from which 3050 (2.92%) animals were considered as infected with *Cysticercus bovis*. Calcified and degenerated cysticerci were more common (65.3%) than live ones (34.7%).

The administrative regions that obtained the highest values of prevalence in the studied period were São José do Rio Preto (9.01%), São José dos Campos (7.69%), Campinas (5.26%), Central (4.22%), Bauru (3.64%) and Marilia (3.07%) (Table 1). In Table 1, it can be observed that the regions of São José do Rio Preto, Campinas, Marília, Central, Bauru, Franca, Ribeirão Preto and São José dos Campos, had higher odds of having an infected animal (OR > 1). However, only Sao José do Rio Preto (OR = 3.32) and Campinas (OR = 1.84) had a confidence interval higher than 1 (95% CI: 2.16–3.54 and 95% CI: 1.05–3.22, respectively).

The dendrogram obtained using cluster analysis is presented in Fig. 3. Two main clusters were observed: G1 = prevalence of cysticercosis; sugar cane harvesting area; orange harvesting area; coffee harvesting area and G2 = HDI general; HDI education; HDI income; and HDI life expectancy. The geospatial distribution of sugar cane (Fig. 4), coffee (Fig. 5), and orange production (Fig. 6) in the state of São Paulo illustrate this variables distribution.

Data of total bovine population (number of animals reared in the state of São Paulo state during 2012 is presented in Fig. 7).

4. Discussion

The established prevalence (2.9%) of bovine cysticercosis was lower than the values reported by Ungar and Germano (1992) and Carvalho et al. (2006) in the state of São Paulo, and in the state of Minas Gerais, where the authors found an average prevalence value of 5.5% and 6.2%, respectively. On the other hand, the prevalence values obtained were similar to those found by Souza et al. (2007) and Guimarães-Peixoto et al. (2012) in the state of Paraná (3.83 and 2.23%, respectively) and by Bavia et al. (2012) in the state of Bahia (0.7%).

Ungar and Germano (1992) analyzed the cysticercosis occurrence also by Administrative Regions in the state of São Paulo and the authors established higher-risk areas as Ribeirão Preto, Bauru and Marília regions. These authors found that significant areas for the occurrence
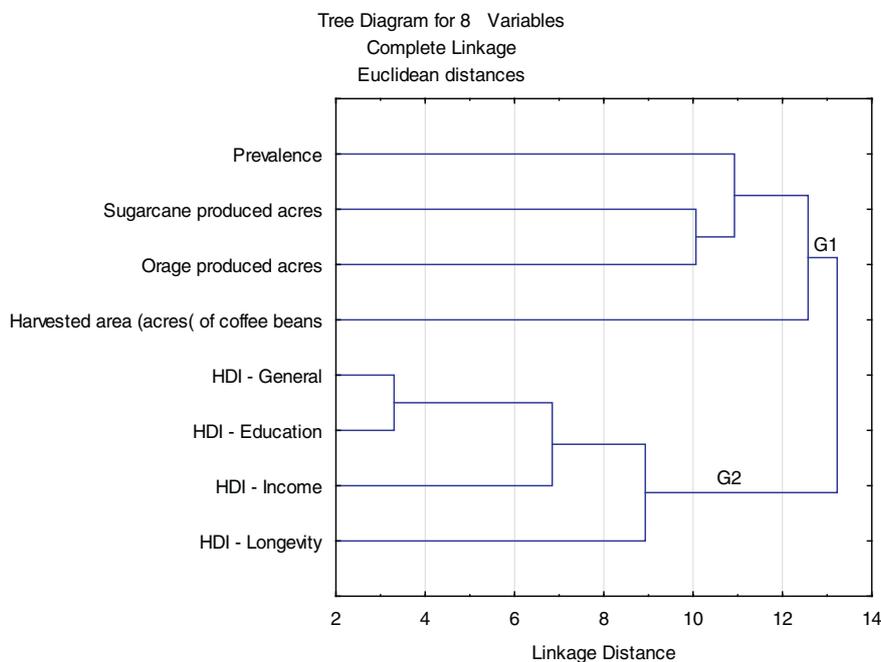
Tree Diagram for 8 Variables
Complete Linkage
Euclidean distances

Fig. 3. Dendrogram generated by cluster analysis of the variables prevalence of bovine cysticercosis, sugarcane, orange and coffe production areas and Human Development Indexes (General, Education, Income and Longevity) using Statistica software.
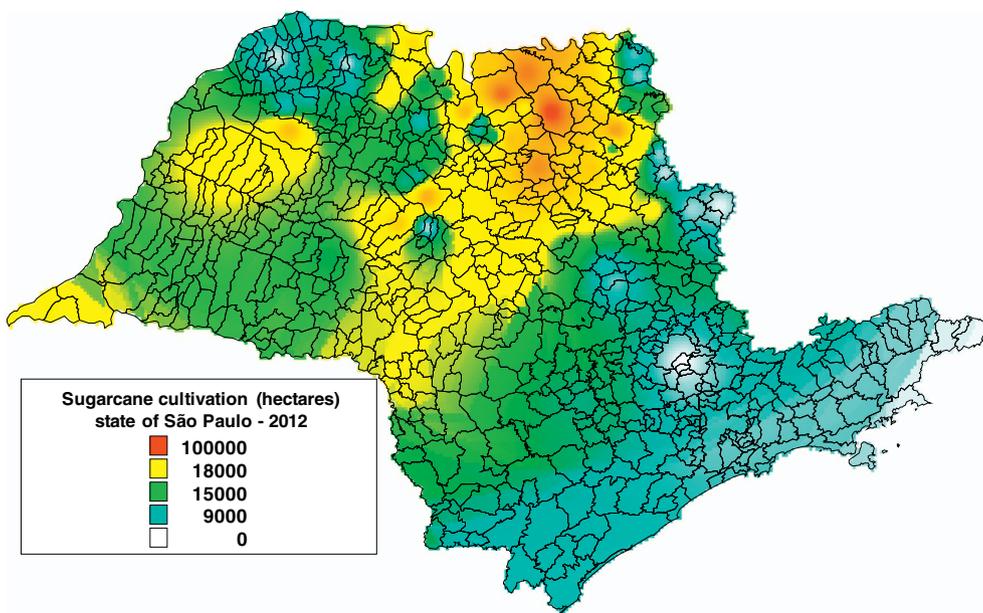

Fig. 4. Spatial distribution of sugarcane production (hectares) by municipality in the state of São Paulo, Brazil, during 2012.

of bovine cysticercosis were those that amounted 80.8% of the state total cattle population. In contrast, in our results the Administrative Regions with higher risk for bovine cysticercosis (São José do Rio Preto and Campinas) hosted only 23.19% of the State total cattle population. From these results, it is possible to infer that bovine cysticercosis occurrence is not strictly related to cattle presence, but more related to the presence of infected humans near areas of bovines rearing.

Regarding to cluster analysis, Haliki et al. (2002a,b) reported that the cluster analysis is performed using statistical indexes that judge the structures found in a group of observations in a quantitative way. Metz

(2006) highlights that the relation among the variables in a cluster is of utter importantce in the discovery process. According to these authors, the use of cluster analysis allows us to identify concepts that can explain the variables within the same cluster. Consequently, it is possible to evaluate subjectively the clusters formation in order to discover the existence of any practical meaning. It was possible to detect a clustering composed by the variables: prevalence of bovine cysticercosis, total area of sugar cane harvested, total area of coffee harvested, total area of orange harversted (G1 cluster) based on the cluster analysis result.

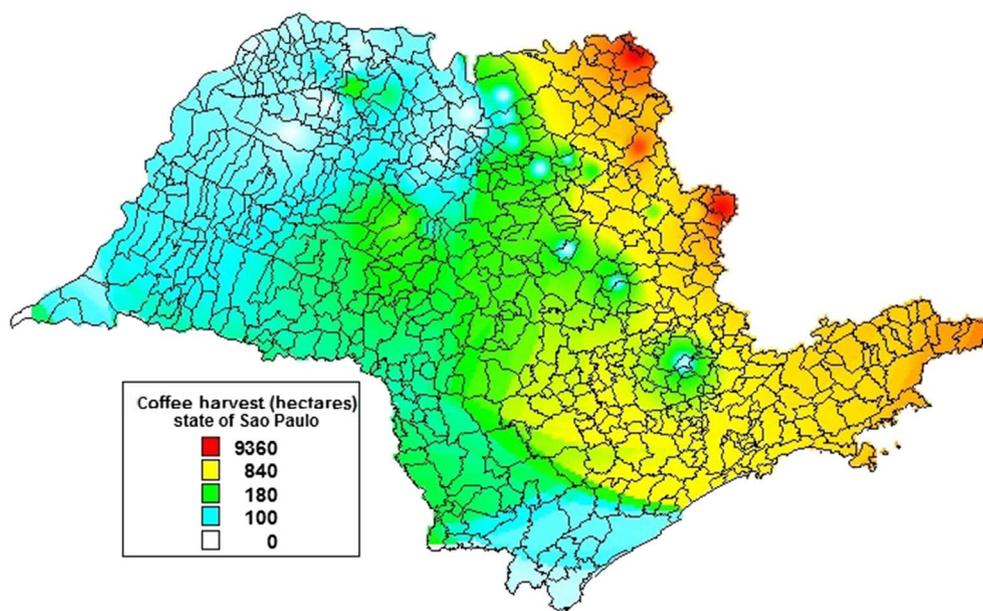Regarding to São José do Rio Preto and Campinas regions, the

Fig. 5. Spatial distribution of coffee harvest (hectares) by municipality in the state of São Paulo, Brazil, during 2012.
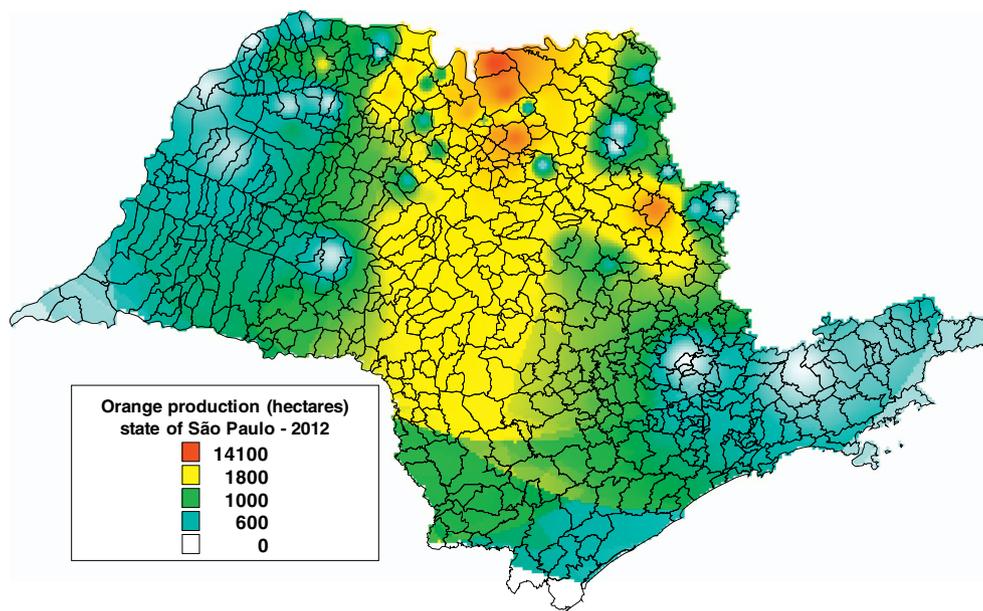

Fig. 6. Spatial distribution of orange production (hectares) by municipality in the state of São Paulo, Brazil, during 2012.

higher risk for bovine cysticercosis occurrence (OR > 1) could be related to some epidemiological features. According to Dedeca et al. (2009), São José do Rio Preto region is the less industrialized in the state of São Paulo. Farming is the main economical activity, responsible for employing > 40% of the inhabitants. The main farming products in this region are cattle, sugar cane, orange and coffe to a lesser extent. As to Campinas region, the coffee and orange are the mainly produced products. Due to the fact that the mountainous topography of those regions precludes the use of machinery, farming on those areas depends on temporary workers that migrate from other places. In conclusion, it is possible that humans with taeniasis could be involved in the bovine cysticercosis in those areas, mainly where harvesting occurs near bovine populations in pastures and there are no bathrooms available for the rural temporary workers. Consequently, such features could justify the significant risk for bovine cysticercosis in São José do Rio Preto and Campinas.

The results found in this study are important to highlight the needs

of prophylatic practices adoption in areas of higher occurrence of bovine cysticercosis in the state of São Paulo. Main measures are related to provide better education for the population and rural temporary workers that might be present in those areas. The adoption of chemical and portable bathrooms for temporary workers is also an advisable measure to reduce environment contamination. Moreover, more studies performed in other regions and slughterhouses are required to assess other possible associations between this complex with socioeconomic and cultural aspects.

In conclusion, it was possible to establish a prevalence of 2.9% in the state of São Paulo during 2012. The regions of São José do Rio Preto and Campinas had the highest numbers of cases (OR > 1). The cluster analysis showed that cyticercosis cases in the municipalities are related to presence of sugar cane, orange and coffee production. These results indicate that the presence of temporary rural workers and socioeconomic and cultural features in each region could contribute to widespread bovine cysticercosis in some areas.
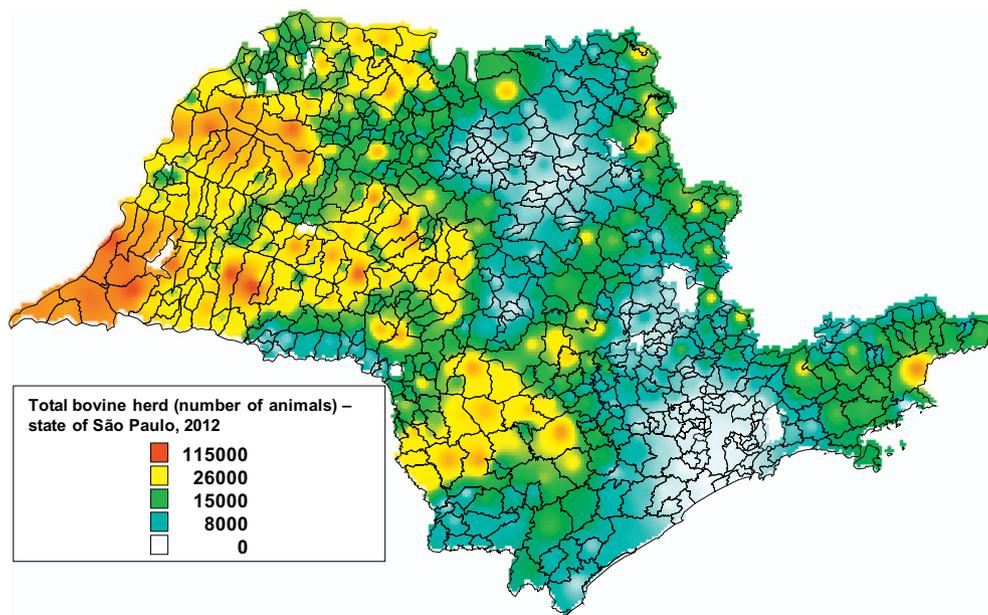
Fig. 7. Spatial distribution of cattle population (number of animals) by municipality in the state of São Paulo, Brazil, during 2012.

References

Bavia, M.E., Carneiro, D.D.M.T., Cardim, L.L., Silva, M.M.N., Martins, M.S., 2012. Spatial scan statistic in the detection of risk areas for bovine cysticercosis in the state of Bahia. Arq. Bras. Med. Vet. Zootec. 64, 1200–1208.

Biondi, G.F., Henrique, C.H., Oliveira, A.C., Castro, A.P., 2000. Evaluation of evagination test efficiency for Taenia saginata metacestodes. Rev. Educ. Cont. CRMV-SP 3, 55–61.

Brazilian Ministry of Agriculture, Lifestock and Food Supply, 1971. Standardization of Techniques, Plants and Equipments. vol. 1. pp. 78–95 (Cattle. Official Gazzete, Brasília, DF).

Brazilian Ministry of Agriculture, Lifestock and Food Supply, 1980. Regulation of Industrial and Sanitary Inspection of Animal Products. (Official Gazzete, Brasilia, DF) 1980.

Brazilian Ministry of Agriculture, Lifestock and Food Supply, 1988. Cysticercosis Scientific Works. (Circular N. 054 de 19 May 1988. Brasília, DF).

Brazilian Ministry of Agriculture, Lifestock and Food Supply, 1997. List of Diseases by Municipality and Origin. Federal Inspection Service (SIF). Disponible in < http://extranet. agricultura.gov.br > (Acessed on 15 set. 2006).

Cabaret, J., Geerts, S., Madeline, M., Ballandonne, C., Barbier, D., 2002. The use of urban sewage sludge on pastures: the cysticercosis threat. Vet. Res. 33, 575–597.

Calvo-Artavia, F.F., Nielsen, L.R., Dahl, J., Clausen, D.M., Alban, L., 2013a. Occurrence and factors associated with bovine cysticercosis recorded in cattle at meat inspection in Denmark in 2004-2011. Prev. Vet. Med. 110, 177–182.

Calvo-Artavia, F.F., Nielsen, L.R., Alban, L., 2013b. Epidemiologic and economic evaluation of risk-based inspection for bovine cysticercosis in Danish cattle. Prev. Vet. Med. 108, 253–261.

Carvalho, L.T., Costa, F.R.F., Santos, I.F., Carvalho, A.L.T., 2006. Measles prevalence in cattle slaughtered under sanitary inspection in Minas Gerais. Rev. Bras. Ciênc. Vet. 12, 109–112.

Costa, R.F.R., Santos, I.F., Santana, A.P., Tortelly, R., Nascimento, E.R., Fukuda, R.T., Carvalho, E.C.Q., Menezes, R.C., 2012. Characterization of Cysticercus bovis lesions at postmortem inspection of cattle by gross examination, histopathology and polymerase chain reaction (PCR). Pesqui. Vet. Bras. 32, 477–484.

Dedeca, C., Montali, L., Baeninger, R., 2009. Regional Economic Studies - São José do Rio Preto. FINEP/NEPP/NEPO/IE. 181pp. Disponible in: http://www.nepo.unicamp.br/simesp/site/Estudos/SJRP.pdf. (Acessed on 21 Sep 2015).

Dupuy, C., Morlot, C., Gilot-Fromont, E., Mas, M., Grandmontagne, C., Gilli-Dunoyer, P., 2014. Prevalence of Taenia saginata cysticercosis in French cattle in 2010. Vet Parasitol. 203, 65–72.

Flütsch, F., Heinzmann, D., Mathis, A., Hertzberg, H., Stephan, R., Deplazes, P., 2008. Case–control study to identify risk factors for bovine cysticer-cosis on farms in Switzerland. Parasitology 135, 641–646.

Guimarães-Peixoto, R.P.M., Souza, V.K., Pinto, P.S.A., Santos, T.O., 2012. Distribution and identification of risk áreas for bovine cysticercosis in the state of Parana. Brazil. Pesq. Vet. Bras. 32, 975–979.

Haliki, M., Batistakis, Y., Vaziirgiannis, M., 2002a. Cluster validity methods: part I. SIGMOD Rec. 31, 40–45p.

Haliki, M., Batistakis, Y., Vaziirgiannis, M., 2002b. Cluster validity methods: part II. SIGMOD Rec. 31, 19–27p.

IBGE, Brazilian Institute of Geographic and Statistics, 2015. Municipalities. Avaiable in http://cidades.ibge.gov.br/ (Acessed on 12 april 2015).

Jenkins, D.J., Brown, G.K., Traub, R.J., 2013. "Cysticercosis storm" in feedlot cattle in north-west New South Wales. Aust. Vet. J. 91, 89–93.

Kyvsgaard, N.C., Ilsoe, B., Willeberg, P., Nansen, P., Henriksen, S.A., 1991. A case–control study of risk factors in light Taenia saginata cysticercosis in Danish cattle. Acta Vet. Scand. 32, 243–252.

Laranjo-González, M., Devleesschauwer, B., Gabriel, S., Dorny, P., Allepuz, A., 2016. Epidemiology, impact and control of bovine cysticercosis in Europe: a systematic review. Parasit. Vectors 9, 1–12.

Lopes, W.D.Z., Santos, T.R., Soares, V.E., Nunes, J.L.N., Mendonça, R.P., Lima, R.C.A., Sakamoto, C.A.M., Costa, G.H.N., Thomaz-Soccol, V.T., Oliveira, G.P., Costa, A.J., 2011. Preferential infection sites of Cysticercus bovis in cattle experimentally infected with Taenia saginata eggs. Res. Vet. Sci. 90, 84–88.

Lopes, W.D.Z., Cruz, B.C., Soares, V.E., Nunes, J.L.N., Teixeira, W.F., Maciel, W., Buzulini, C., Pereira, J.C., Felippelli, G., Soccol, V.T., Oliveira, G.P., Costa, A.J., 2014. Historic of therapeutic efficacy of albendazol sulphoxide administered in different routes, dosages and treatment schemes, against Taenia saginata cysticercus in cattle experimentally infected. Exp. Parasitol. 137, 14–20.

Metz, J., 2006. Interpretação de clusters gerados por algoritimos de clustering hierárquico. Dissertação de Mestrado Instituto de Ciências Matemáticas e Computação da Universidade de São Paulo – ICMC/USP (126 p).

Praet, P.D.N., 2007. Taenia saginata in Europe. Vet. Parasitol. 149, 22–24.

Rossi, G.A.M., Hope, E.G., Mathias, L.A., Martins, A.M.C.V., Mussi, L.A., Prata, L.F., 2015. Bovine cysticercosis in slaughtered cattle as an indicator of Good Agricultural Practices (GAP) and epidemiological risk factors. Prev. Vet. Med. 118, 504–508.

Rossi, G.A.M., Simoni, H.A.S., Lopes, W.D.Z., Almeida, H.M.S., Soares, V.E., Vidal, A.M.C., Ferraudo, A.S., Mathias, L.A., 2016. Prevalence and geospatial distribution of bovine cysticercosis in the state of Mato Grosso. Brazil. Prev. Vet. Med. 130, 94–98.

Schantz, P.M., Cruz, M., Sarti, È., Pawlowski, Z.S., 1994. La erradicabilidad potencial de la teniasis y la cisticercosis. Boln Of. San. Panam. 5, 458–465.

Souza, W.K., Pessôa-Silva, M.C., Minozzo, J.C., Thomaz-Soccol, V., 2007. Bovine cisticercosis prevalence in Parana state, southern of Brazil, in animals slaughtered under the SIF 1710. Semina: Ciênc. Agrárias 28, 675–684.

Ungar, M.L., Germano, P.M.L., 1992. Bovine cysticercosis prevalence in the State of São Paulo. Brazil. Rev. Saúde Publ. 26, 167–172.