

Analysis of 15 years of the National Program for the Control and Eradication of Animal Brucellosis and Tuberculosis, Brazil

Avaliação de 15 anos do Programa Nacional de Controle e Erradicação da Brucelose e Tuberculose, Brasil

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Abstract

In 2001, Brazil launched the National Program for Control and Eradication of Animal Brucellosis and Tuberculosis (PNCEBT). After 15 years, it can be checked that there were mistakes and successes in driving the program, but it is undeniable that in this period, a series of structuring actions was initiated. In addition, a large volume of high-quality epidemiological data were produced, which will allow the country to move forward more rationally and safely in combating these two diseases. Today, Brazil has a sufficient contingent of veterinarians to develop the accreditation of farms and vaccination against brucellosis in all States; all batches of vaccines against brucellosis produced by private laboratories are controlled by an official laboratory; the brucellosis vaccination program is well established in most States and it has produced a decrease in prevalence in Mato Grosso, Mato Grosso do Sul, Rondônia and Minas Gerais; there are two ongoing eradication experiences: of brucellosis in Santa Catarina and of tuberculosis in Mato Grosso; nowadays there is a culture to combat brucellosis and tuberculosis in the Brazilian Official Veterinary Services. The epidemiological situation of bovine brucellosis and tuberculosis is well known in the major part of the country. However, progress has been limited by the difficulty in engaging the beef and dairy productive chains as true partners in the process.

Key words: Bovine tuberculosis. Bovine brucellosis. Control, Eradication program, Brazil.

Resumo

O Brasil lançou, em 2001, o Programa Nacional de Controle e Erradicação da Brucelose e Tuberculose (PNCEBT). Passados 15 anos, pode-se verificar que houve erros e acertos na condução do programa, porém é inegável que nesse período foi iniciada uma série de ações estruturantes, bem como produzido um grande volume de informações epidemiológicas de alta qualidade que permitirão ao País avançar com mais racionalidade e segurança no combate a essas duas doenças. Já existe um contingente suficiente de médicos veterinários para desenvolver a certificação de propriedades e a vacinação contra brucelose

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em todos os Estados; todos os lotes de vacinas contra brucelose produzidos por laboratórios privados são controlados por laboratório oficial; o programa de vacinação contra brucelose está bem implantado na maioria dos Estados e já produziu a diminuição da prevalência nos Estados de Mato Grosso, Mato Grosso do Sul, Rondônia e Minas Gerais; existem duas experiências de erradicação em curso: de brucelose em Santa Catarina e de tuberculose em Mato Grosso; hoje existe uma cultura de combate à brucelose e à tuberculose nos Serviços Veterinários Oficiais dos Estados e da Federação. A situação epidemiológica da tuberculose bovina é conhecida em detalhes em 13 Estados e a da brucelose bovina em 18. No entanto, a evolução tem sido limitada pela dificuldade em engajar as cadeias produtivas de carne e leite como verdadeiros parceiros no processo.

Palavras-chave: Tuberculose bovina. Brucelose bovina. Controle. Erradicação. Programa. Brasil.

Introduction

In 2001, Brazil launched the National Program for the Control and Eradication of Animal Brucellosis and Tuberculosis (PNCEBT). This novel program was established and was later assisted by an Advisory Scientific Committee that included staff from the Ministry of Agriculture, Livestock and Supply (MAPA) as well as experts from various educational and research institutions in Brazil. This group has also collaborated with foreign researchers and individuals with recognized expertise in this area.

After 15 years, we can identify the errors and successes of the program, but it is undeniable that in this period, a series of structuring actions was initiated, and a large volume of high-quality epidemiological data were produced, which will allow the country to move forward more rationally and safely in combating these two diseases. However, progress has been limited by the difficulty in engaging the beef and dairy productive chains as true partners in the process.

Some of the structuring actions include the accreditation of veterinarians to perform diagnostic tests for brucellosis and tuberculosis and implementation of farm free-accreditation processes, registration of professionals for vaccination of heifers against brucellosis, official control of all batches of vaccines against brucellosis produced by private laboratories, deployment of a consistent vaccination program against brucellosis in the vast majority of the States, and, finally and most importantly, the creation and development of

an anti-brucellosis and tuberculosis culture in the Official Veterinary Services of the States and the Federation.

High-quality epidemiological data has revealed details regarding the status of brucellosis in 18 federative units, which contain approximately 85% of the Brazilian bovine herd. Of these, eight conducted a second study on brucellosis to verify the effectiveness of the implemented measures, in order to improve management of the control/eradication processes.

With regard to tuberculosis, studies have detailed the epidemiological status in 13 states, which include 75% of the Brazilian bovine herd.

This epidemiological characterization of brucellosis and tuberculosis in Brazil was coordinated by the Collaborating Centre for Animal Health of MAPA, which is based in the Faculty of Veterinary Medicine and Animal Science (FMVZ) of the University of São Paulo (USP).

Epidemiological Status of Brucellosis

In 2009, a special supplement of the *Arquivo Brasileiro de Medicina Veterinária e Zootecnia* (Brazilian Journal of Veterinary and Animal Science) was published, completely dedicated to the dissemination of initial data on the status of brucellosis in 15 federative units in Brazil, namely: Rio Grande do Sul, Santa Catarina, Paraná, São Paulo, Minas Gerais, Espírito Santo, Rio de Janeiro, Mato Grosso do Sul, Mato Grosso, Rondônia, Goiás, Distrito Federal, Tocantins, Bahia, and

Sergipe (ALVES et al., 2009; AZEVEDO et al., 2009; CHATE et al., 2009; DIAS et al., 2009a, 2009b; GONÇALVES et al., 2009a, 2009b; KLEIN-GUNNEWIEK et al., 2009; MARVULO et al., 2009; NEGREIROS et al., 2009; OGATA et al., 2009; ROCHA et al., 2009; SIKUSAWA et al.,

2009; SILVA et al., 2009; VILLAR et al., 2009). A 2013 article described the situation in Maranhão (BORBA et al., 2013), and this supplement presents the results for Pernambuco and Paraíba (ALMEIDA et al., 2016; CLEMENTINO et al., 2016). Figure 1 shows a map with the Brazilian federative units.

Figure 1. Brazilian federative units.



Figures 2 and 3 provide a summary of these findings, showing a great heterogeneity between and within federative units. The highest prevalence of both infected herds and animals tend to be observed in federative units in the Midwest region as well as neighboring states, which are known for beef production. Santa Catarina is the only state with very low prevalence of brucellosis in all regions. It is also a state in which vaccination of heifers with the B19 strain has been prohibited since

2004, and eradication strategies are currently being implemented with the structuring of a surveillance system for detection and mitigation of residual infected herds. The other federative units displayed higher prevalence, consistent with the adoption of vaccination. Therefore, they have implemented vaccination programs based on administration of the B19 strain in order to reduce prevalence rates with the lowest possible cost of investment.

Figure 2. First standardized studies on the prevalence of brucellosis-seropositive cattle in Brazil.

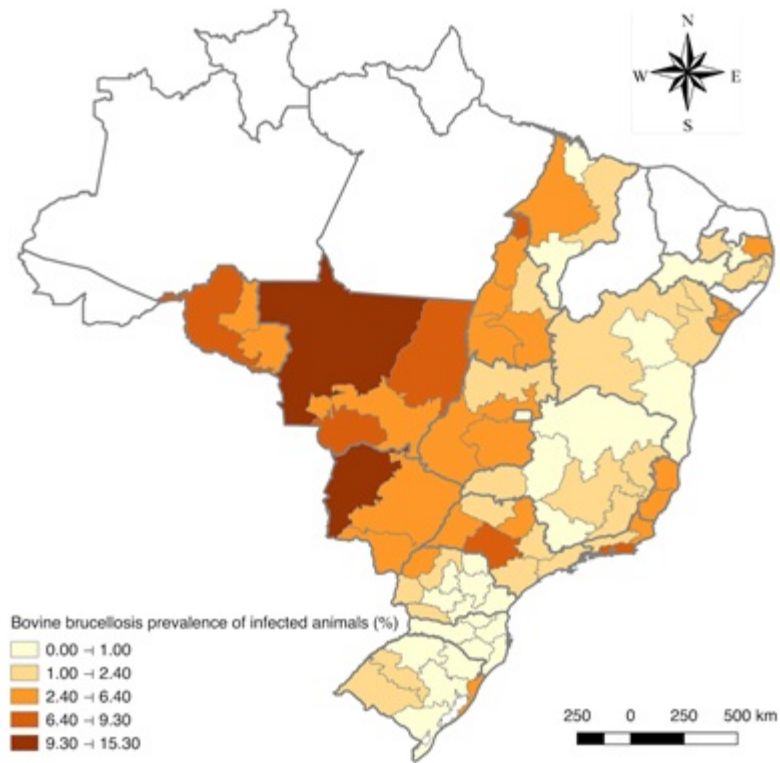
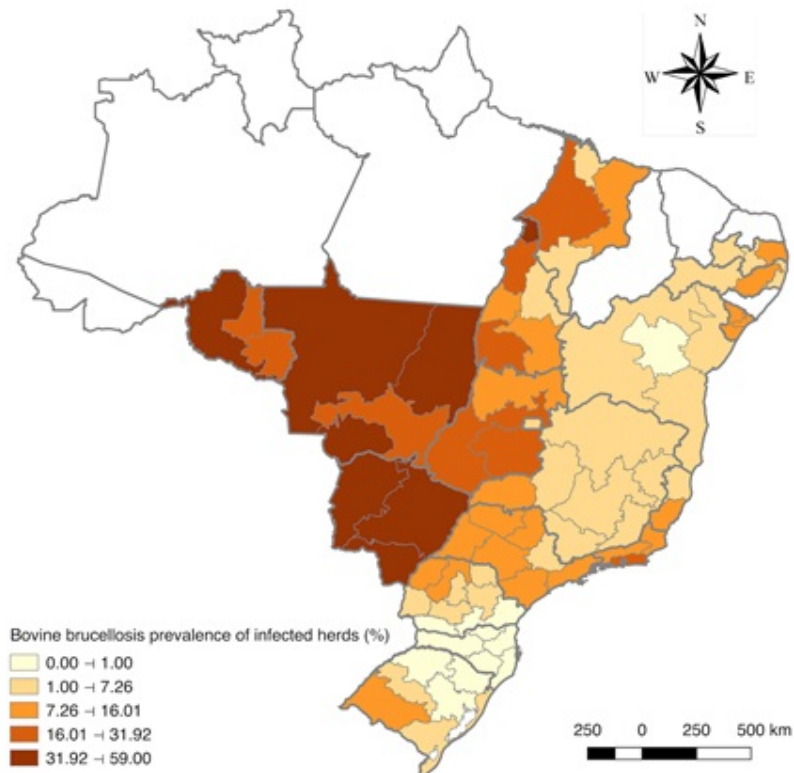


Figure 3. First standardized studies on the prevalence of bovine brucellosis-infected herds in Brazil.



Approximately 10 years after the first study on the epidemiological status of bovine brucellosis, the States of Rondônia, Mato Grosso, Mato Grosso do Sul, São Paulo, Minas Gerais, Espírito Santo, and Rio Grande do Sul carried out a second study to determine whether there was a decrease in the prevalence in accordance with the implemented vaccination programs (BARDDAL et al., 2016; DIAS et al., 2016a; ANZAI et al., 2016; INLAMEA et al., 2016; LEAL FILHO et al., 2016; OLIVEIRA et al., 2016; SILVA et al., 2016b). The state of

Santa Catarina, which has begun implementing an eradication strategy, also performed a second study to estimate the prevalence of brucellosis and to monitor its progress since 2001, when the first study was performed (VILLAR et al., 2009; BAUMGARTEN et al., 2016). Table 1 and Figure 4 show that the vaccination program led to the lowering of the prevalence of infected herds in Minas Gerais, Rondônia, Mato Grosso, and Mato Grosso do Sul. Figures 5 and 6 present the latest prevalence data of bovine brucellosis in the Brazilian federative units.

Table 1. Comparison of the prevalence of bovine brucellosis-infected herds (P) between the first and second studies conducted in Brazilian states, with an interval of approximately 10 years.

State	First study			Second study		
	Year	P (%)	95% CI (%)	Year	P (%)	95% CI (%)
Minas Gerais	2002	6.04	4.98 – 7.10	2011	3.59	2.76 – 4.42
Rondônia	2004	35.18	32.09 – 38.36	2014	12.3	10.3 – 14.6
Mato Grosso	2003	41.2	38.0 – 44.4	2014	24	21.3 – 26.8
Mato Grosso do Sul	1998	41.5	36.5 – 44.7	2009	30.6	27.4 – 34.0
Espírito Santo	2002/2003	9.0	6.97 – 11.55	2012/2014	9.3	7.1 – 11.8
Rio Grande do Sul	2004	2.06	1.50 – 2.63	2013	3.54	2.49 – 4.88
São Paulo	2001	9.7	7.80 – 11.60	2011	10.2	8.8 – 11.8
Santa Catarina	2001	0.32	0.10 – 0.69	2012	0.91	0.30 – 2.11

Figure 4. Results of studies on the prevalence of bovine brucellosis-infected herds conducted in Brazilian states, with an interval of approximately 10 years.

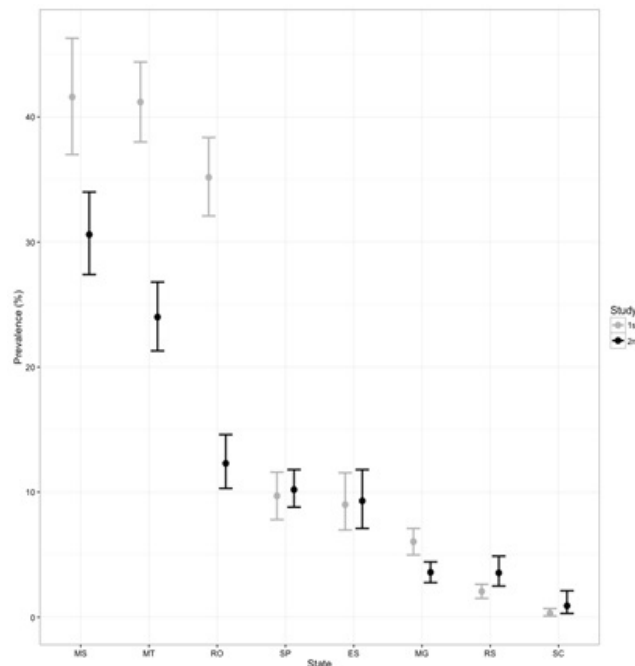


Figure 5. Latest studies on the prevalence of seropositive cows for bovine brucellosis carried out in the Brazilian states (2016).

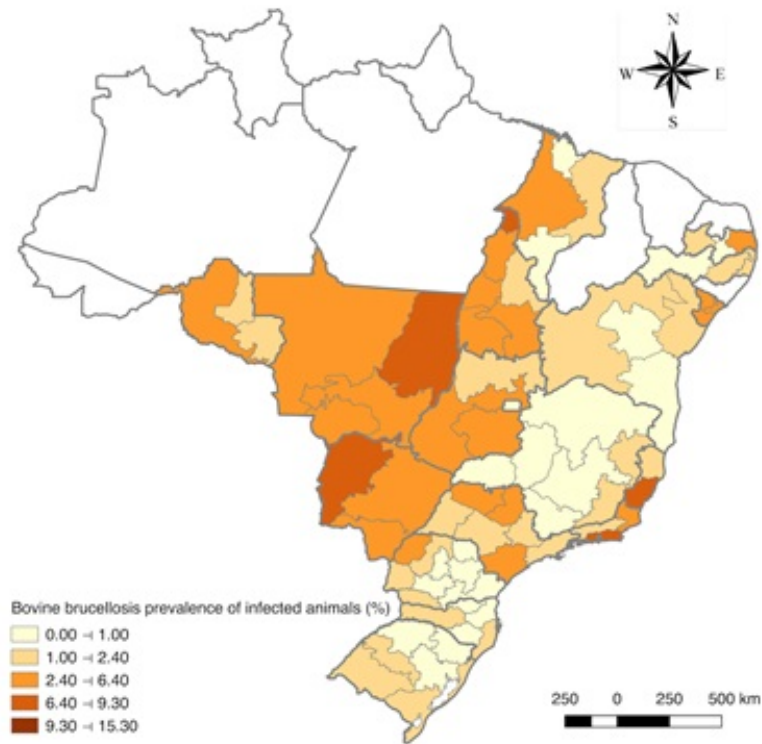
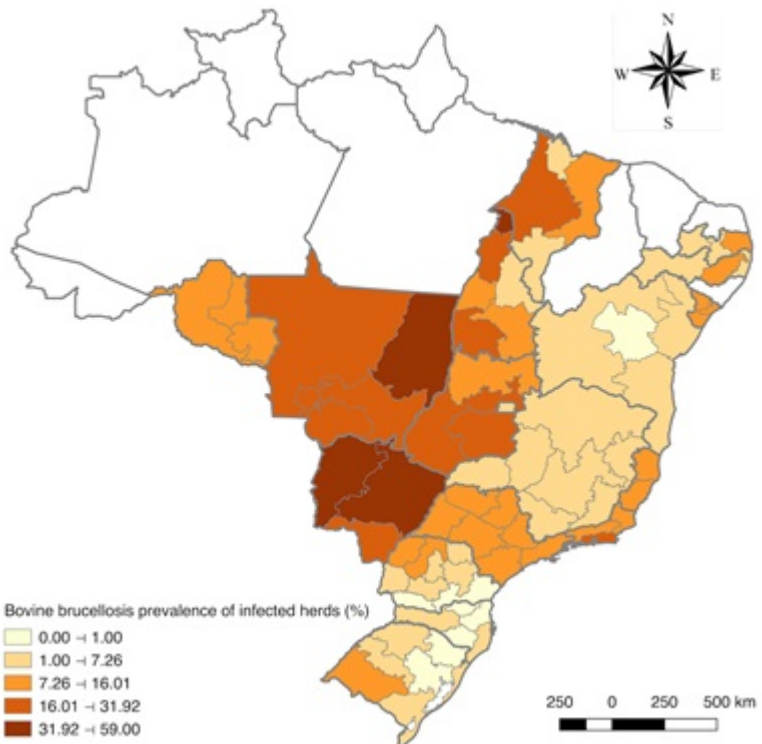


Figure 6. Latest studies on the prevalence of herds infected for bovine brucellosis carried out in the Brazilian states (2016).



Eighteen of the federative units above have also assessed risk factors for infection; the main variable associated with bovine brucellosis infection was increased herd size (MOTA, 2011). Some traits of larger herds facilitate the transmission of brucellosis, especially the increased replacement of animals (CRAWFORD et al., 1990). Thus, this variable indirectly suggests that replacement of animals, practiced with more frequency in larger herds, is associated with the introduction of the disease on a farm. Another variable systematically identified as a risk factor was the introduction of breeding animals without prior diagnostic testing.

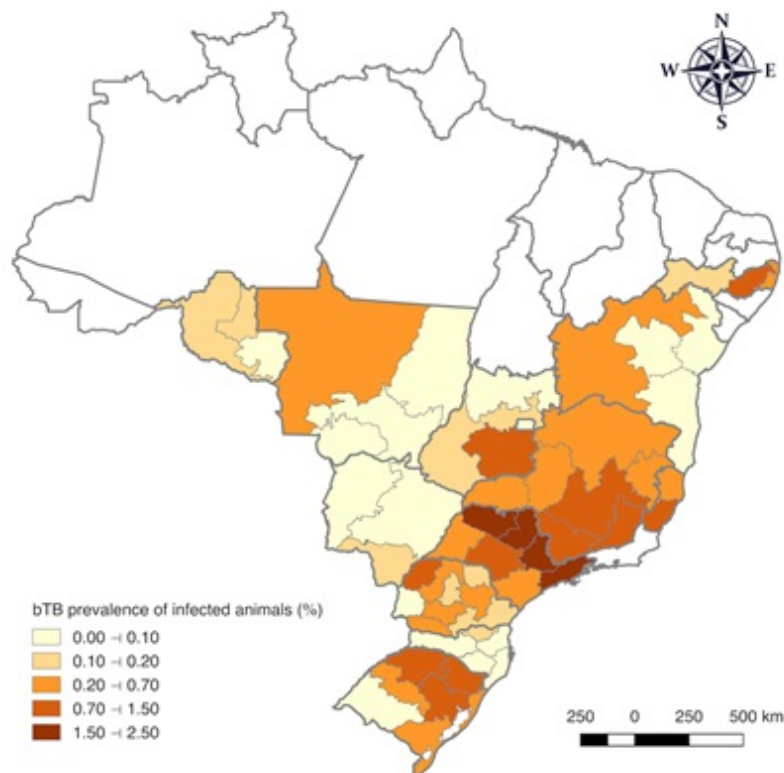
In conclusion, what contributed most to the spread of bovine brucellosis in Brazil was the introduction of animals without testing them, which can be solved with a massive health education

program to inform farmers about the importance of testing breeding animals before introduce them in their farms.

Epidemiological Status of Tuberculosis

This supplement presents the results of the first studies on bovine tuberculosis conducted in 13 federative units, which include 75% of the Brazilian herd (BAHIENSE et al., 2016; BARBIERI et al., 2016; DIAS et al., 2016b; GALVIS et al., 2016; GUEDES et al., 2016; LIMA et al., 2016; NÉSPOLI et al., 2016; QUEIROZ et al., 2016; RIBEIRO et al., 2016; ROCHA et al., 2016; SILVA et al., 2016a; VELOSO et al., 2016; VENDRAME et al., 2016). The situation is heterogeneous among and within states, as shown in Figures 7 and 8.

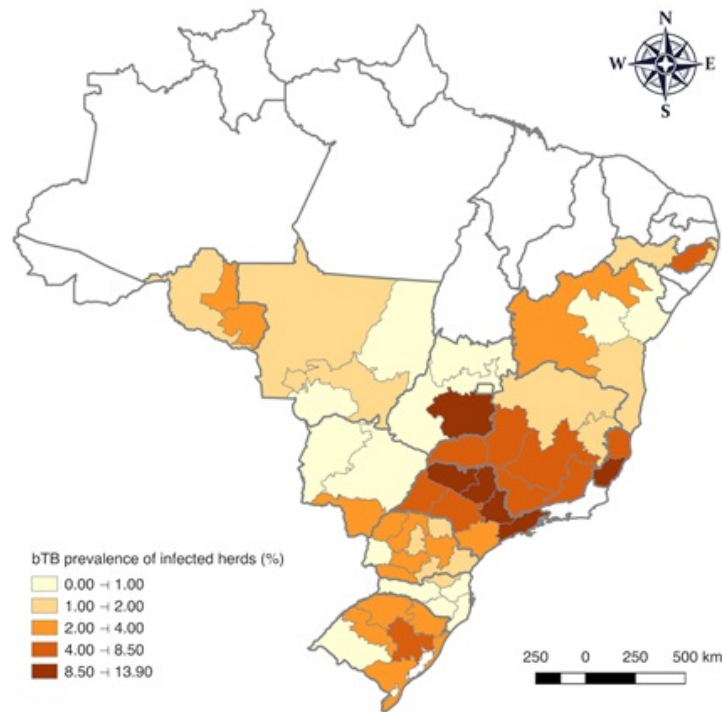
Figure 7. Prevalence of tuberculin test-positive cattle in Brazil (2016).



Figures 7 and 8 indicate a higher prevalence in the state of Espírito Santo, north of São Paulo, south of Minas Gerais, and southern Goiás, coinciding with the milk-producing belt in Brazil. Dairy and mixed herds are more vulnerable to tuberculosis, since milk production requires the agglomeration

of animals during milking, which increases the risk of transmission (BARLOW et al., 1997), a fact that increases the cattle population density and consequently the likelihood of infectious contacts (HUMBLET et al., 2010; ALVAREZ et al., 2012).

Figure 8. Prevalence of bovine tuberculosis-infected herds in Brazil (2016).



In these 13 states, the main risk factors identified by the studies were milk production, particularly in farms with some degree of sophistication in the mode of production, and having a larger number of cows.

In addition, dairy cattle tend to be older than animals from beef herds, and therefore present a higher probability of disease exposure (HUMBLET et al., 2009). Herds with more sophisticated production modes tend to be denser and their animals more stressed; these factors favor the transmission of tuberculosis (HUMBLET et al., 2009, 2010).

Larger herds have higher replacement rates, thus increasing the risk of introduction of infected

animals. The purchase of animals, in particular from high-risk properties, plays an essential role in the transmission of bovine tuberculosis (REILLY; COURTENAY, 2007; OLOYA et al., 2007; TSCHOPP et al., 2009; RAMÍREZ-VILLAESCUSA et al., 2010; SKUCE et al., 2012; BESSELL et al., 2012). Hence, it is plausible to assume that this variable indicates that the purchase of animals without prior testing increases the risk of introducing bovine tuberculosis to a farm.

In conclusion, bovine tuberculosis in Brazil is more prevalent in dairy farms, especially high-production farms. The introduction of animals without testing has been the primary contributor

to this problem, which can be solved with a health education program to inform farmers about the importance of testing animals before introduce them in their farms.

Brucellosis Vaccination

Vaccination of heifers between three and eight months of age with the B19 strain is compulsory throughout the national territory, except for the state of Santa Catarina, where it is prohibited due to the low prevalence of infected herds (0.32% [0.10, 0.69%]) and animals (0.06% [0.0-0.17%]) (SIKUSAWA et al., 2009).

For cows older than eight months, farmers may vaccinate with the non-agglutinogenic or non-antibody-producing vaccine, also known as RB51 (BRASIL, 2007). The adoption of this second, voluntary, vaccine aimed to achieve high vaccine

coverage of cows of breeding age in the shortest possible time, since with the B19 strain, because of the age restriction for vaccination, this objective would be achieved only after a time equivalent to the average age of slaughtering reproductive cows.

Figure 9 shows that, since implementation of the PNCEBT, the production of B19 has grown in Brazil, plateauing from 2006. Figure 10 shows the same data for the RB51 vaccine, whose production decreased in 2009 before increasing in 2011. We believe that the lack of farmer interest in the RB51 vaccine was the result of an inefficient dissemination of information regarding the role of the vaccine in the context of the PNCEBT. Currently, this framework is slowly reverting, even with the adoption of this vaccine as an alternative to B19 in areas with challenging management of cows, as in the Pantanal region in the states of Mato Grosso e Mato Grosso do Sul.

Figure 9. Number of B19 doses produced by private laboratories and approved by the Brazilian Official Laboratory (Lanagro-MG), from 2002 to 2014.

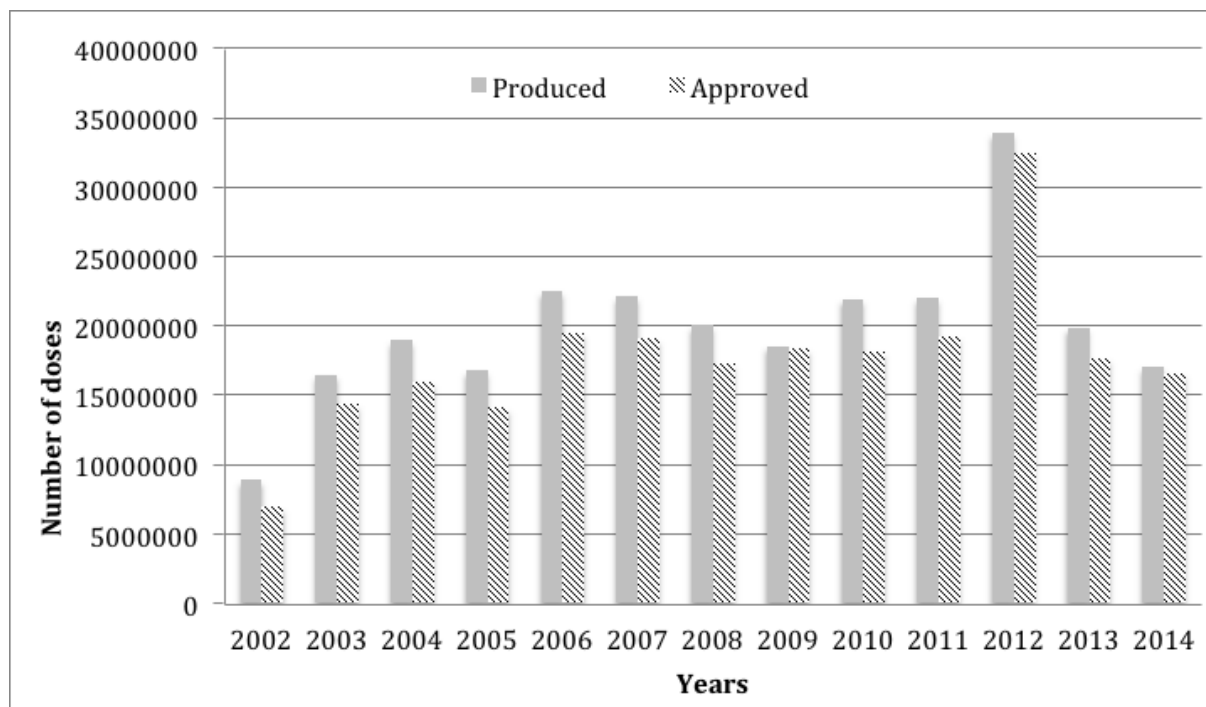
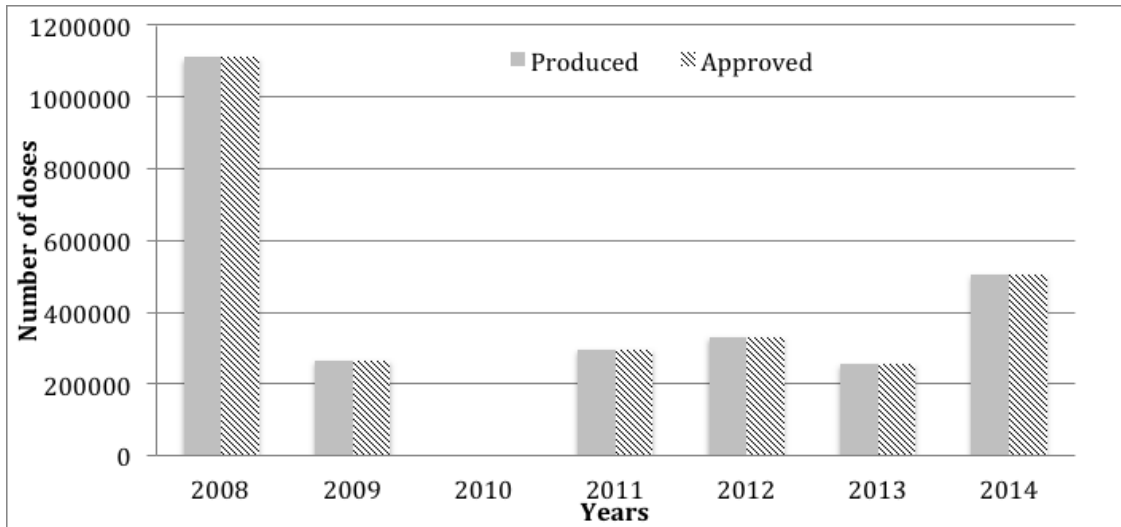


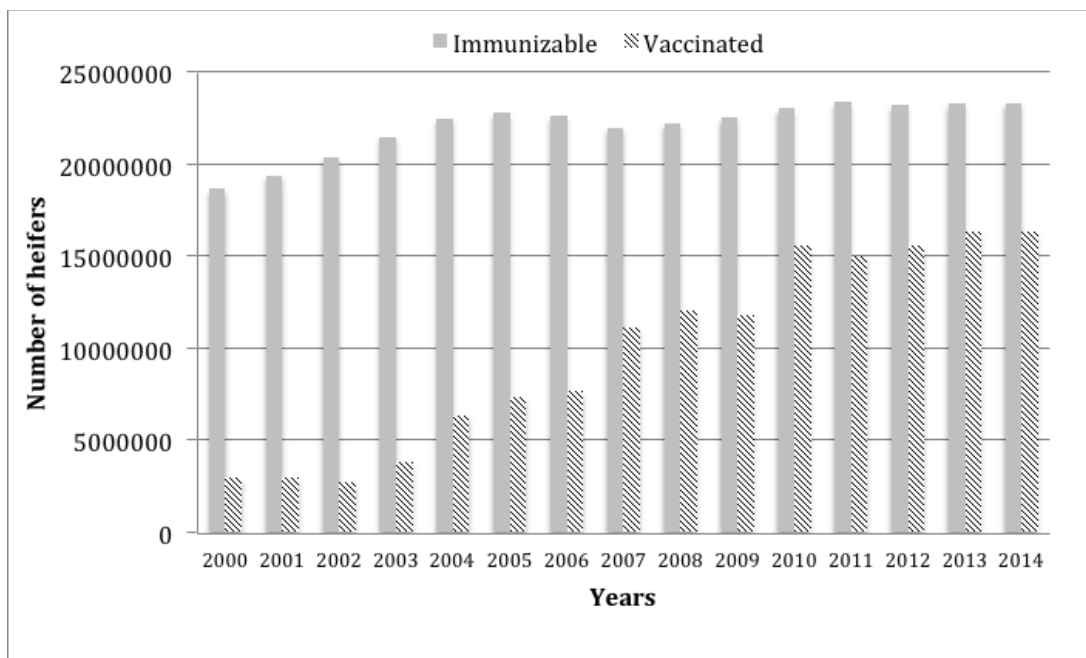
Figure 10. Number of RB51 doses produced by private laboratories and approved by the Brazilian Official Laboratory (Lanagro-MG), from 2008 to 2014.



Since the launch of the PNCEBT, there has been a significant increase in the number of heifers vaccinated with B19, especially from 2004 (Figure 11). It is important to stress that there is a large heterogeneity in the quality of the practice among states. Minas Gerais is the best example of success in this country. In 1980 the state had a prevalence

of seropositive cows of 6.57%, decreasing to 0.81% in 2012 through a compulsory vaccination program with the B19 strain launched in 1993 (PAULIN; FERREIRA NETO, 2003; OLIVEIRA et al., 2016). This result is an important example of the impact of B19 on the reduction of the prevalence of bovine brucellosis in the Brazilian productive environment.

Figure 11. Change in the number of heifers vaccinated with the B19 vaccine in Brazil since 2000.



Veterinarian Accreditation

With the objective of homogenizing conducts and procedures, especially diagnostic procedures, and to disseminate the policies, goals, and initiatives of the PNCEBT, starting in 2001, the MAPA created a accreditation process for veterinarians. To qualify, professionals must pass a course, “Training methods of diagnosis and control of animal brucellosis

and tuberculosis and notions of Transmissible Spongiform Encephalopathies (EET),” authorized by the MAPA and facilitated by educational and research institutions nationwide. Table 2 describes the number of authorized institutions offering these courses, as well as accredited veterinarians in the federative units, showing the success of this initiative and good coverage nationwide.

Table 2. Number of institutions authorized by the MAPA to offer training courses and accredited veterinarians in each federative unit in Brazil, 2015.

Federative unit	Institutions authorized by the MAPA to offer accreditation courses	Accredited veterinarians
Acre	1	16
Alagoas	2	28
Amazonas	0	17
Amapá	0	4
Bahia	2	109
Ceará	1	107
Distrito Federal	1	22
Espírito Santo	1	101
Goiás	1	297
Maranhão	1	82
Minas Gerais	5	736
Mato Grosso do Sul	4	299
Mato Grosso	1	264
Pará	2	127
Paraíba	1	104
Pernambuco	1	87
Piauí	1	25
Paraná	10	794
Rio de Janeiro	1	225
Rio Grande do Norte	0	37
Rondônia	1	68
Roraima	0	1
Rio Grande do Sul	6	594
Santa Catarina	1	399
Sergipe	0	31
São Paulo	9	859
Tocantins	1	51
TOTAL	54	5484

Diagnostic Laboratory Support

Accredited veterinarians can perform all three tuberculin tests recommended by the PNCEBT for the diagnosis of tuberculosis, as well as screening tests for diagnosis of brucellosis, including the buffered acidified antigen test (BAA) and the milk ring test (MRT) (LAGE et al., 2006). The confirmatory tests for the diagnosis of brucellosis – the complement fixation test and the 2-mercaptoethanol test and

fluorescent polarization assay – can be performed only by official laboratories or those accredited by the MAPA (LAGE et al., 2006; BRASIL, 2010). Table 3 shows the location and number of these laboratories, demonstrating the limited size and coverage of this network. However, increased demand for confirmatory tests for the diagnosis of brucellosis will likely lead to a proportional increase in the network of accredited laboratories.

Table 3. Official and MAPA-accredited laboratories for the diagnosis of bovine brucellosis in Brazil, 2015.

Federative unit	Laboratories	
	Accredited	Official
Distrito Federal	1	0
Goiás	1	0
Maranhão	1	0
Minas Gerais	2	1
Pará	0	1
Paraná	2	0
Rio Grande do Sul	1	0
Santa Catarina	1	0
São Paulo	1	0
Total	10	2

Farm Certification

Following international guidelines, the PNCEBT recommends a voluntary certification process for disease-free and monitored herds.

The central idea is that the industry, represented by the dairy industry and slaughterhouses, would differently remunerate milk and meat from certified farms, thus stimulating producer adherence due to the non-negligible costs of processing, as reported by economic studies of this issue (LÔBO, 2008; LEITE, 2012). However, this has not happened, and the results of the certification program have been

disappointing (Table 4). The lack of compensation funds for replacement of positive animals, found in most federative units by the OIE in the “2014 Evaluation of Veterinary Services in Brazil”, considerably limits testing and elimination of positive animals. The best numbers were recorded in the state of Rio Grande do Sul, which triggered a mass municipal certification program, financed in part with public resources. However, the 829 production units certified in this State represent only about 0.25% of the cattle farms with reproductive activity.

Table 4. Numbers of certified tuberculosis and brucellosis-free herds in Brazilian federative units, 2015.

Federative unit	Certified Herds	
	Free	Monitored
Bahia	17	0
Ceará	0	0
Distrito Federal	1	0
Espírito Santo	2	0
Goiás	4	0
Minas Gerais	38	0
Paraíba	1	0
Pernambuco	1	0
Piauí	0	2
Paraná	46	0
Rio de Janeiro	3	0
Rio Grande do Norte	1	0
Rondônia	1	0
Rio Grande do Sul	829	0
Santa Catarina	137	0
São Paulo	21	1
Total	1102	3

New Directions of the PNCEBT

Every successful animal health program is dynamic and often has to be updated as the epidemiological situation evolves and new technologies emerge. The PNCEBT was reviewed in 2015 by a working group of the MAPA, which drafted a document, subject to public consultation, which proposed the following:

1) Flexibility in the use of the RB51 vaccine, creating conditions for high levels of vaccination coverage to be achieved in less time, accelerating the reduction of prevalence, as predicted by Souza et al. (2016);

2) Creation of minimum criteria for the sanitization of properties, giving States the option to modulate the routine tests on the basis of the risk of spread of diseases within their territories, which will have special importance for implementation of eradication strategies and surveillance systems;

3) Reduction from three to two tests of negative herds to certify free properties, facilitating adherence of producers to the certification mechanisms;

4) Method for ranking the federative units, taking into account the prevalence and the actions implemented, ranking States in accordance with the degree of risk in relation to animal brucellosis and tuberculosis. The aim is to create a simple indicator for comparison between federative units, fostering exchange of experiences and healthy competition.

Conclusions

The structuring actions implemented by the PNCEBT produced satisfactory results. We have a sufficient number of veterinarians qualified to certify properties and enrolled for vaccination against brucellosis in all federative units; all batches of vaccine against brucellosis produced by private laboratories are controlled by official laboratories; the vaccination program against bovine brucellosis is well-established in most States; and there is now a culture of combating brucellosis and tuberculosis in the Brazilian Official Veterinary Services.

Since 2004, there has been a significant increase in the number of heifers vaccinated with the B19

vaccine, although a large heterogeneity persists in the quality of the practice among states. Minas Gerais, having begun its compulsory vaccination program in 1993, has significantly reduced the prevalence of brucellosis-infected animals and herds, generating reference data on the impact of B19 in the Brazilian production environment. The higher the vaccination coverage, the faster the reduction of prevalence (AMAKU et al., 2009). The lack of interest of the farmers in the RB51 vaccine is the result of an inefficient dissemination of the role of this vaccine in the context of the PNCEBT. However, this situation is slowly reversing and RB51 was even adopted as an alternative to B19 in areas of difficult management of cows, such as in the Pantanal. We believe that the quality of the vaccination program in the states can be improved by a massive health education program with a focus on farmers and coercive measures to non-compliers. Cross-sectional studies on brucellosis in the federative units have served as an important tool for the management of this process, because they robustly assess the effects of the quality of vaccination programs on lowering the prevalence of brucellosis.

Santa Catarina is the only state that meets the conditions for implementation of strategies for the eradication of brucellosis, as it presents very low prevalence in all regions. Thus, vaccination with B19 was banned and a surveillance system is being structured to detect and mitigate residual infected herds, which could serve as a model for the rest of the country.

With regard to bovine tuberculosis, higher prevalence was observed in the large dairy belt in Brazil, represented by the state of Espírito Santo, northern São Paulo, Southern Minas Gerais and Eastern Central of Goiás. Prevalence rates are low in the rest of the country, especially in those areas more specialized in beef production. Throughout the country, bovine tuberculosis is more concentrated in dairy herds, especially high-production ones and the

introduction of new animals without testing is the primary risk factor associated with its spread. Thus, states that wish to move quickly in their fight against bovine tuberculosis should build surveillance systems for the detection and mitigation of infected herds, preferably incorporating elements of risk-based surveillance. Mato Grosso is a pioneer in the implementation of a surveillance system for bovine tuberculosis; its experience could serve as a model for the rest of the country.

For both diseases, a very well structured health education program should be initiated to encourage farmers perform diagnostic tests before introducing breeding animals to their herds.

The certification program of herds, which is voluntary and entails a large cost for the farmers, unfortunately has not produced satisfactory results, because dairy and beef industries do not differently compensate products from certified herds. It is reasonable to assume that the herd certification process would benefit greatly from the establishment of compensation funds to support the replacement of positive animals, as well as marketing actions aimed at the consumers of dairy and beef, encouraging them to prefer products from brucellosis and tuberculosis-free herds. Of course, this process would depend on the simultaneous adoption of a seal of sanitary quality stamped on products, increasing the added value of the products and allowing for better compensation for the producers of certified properties.

In conclusion, recent changes in the PNCEBT will allow to achieve high levels of vaccination coverage in less time; will enable the states to modulate the routine of testing according to the risk of spread of diseases in their territories; will reduce the costs of certification of disease-free herds; and will allow more direct comparison of the epidemiological status between the federative units, which will foster the exchange of experience as well as healthy competition.

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