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REVIEWS

Paratuberculosis in Latin America: a systematic review

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Abstract Latin America is the definition of the American group, where languages of Latin origin are spoken, including countries in South, Central, and North America. Paratuberculosis is a gastrointestinal contagious chronic disease that affects ruminants, whose etiological agent is the bacilli *Mycobacterium avium* subsp. *paratuberculosis* (MAP). Paratuberculosis is characterized by intermittent diarrhea, decreased milk production, dehydration, and progressive weight loss and is possibly involved in Crohn's disease, a human intestinal disease. MAP is resistant to environmental factors, pasteurization, and water disinfection, which coupled with the subclinical-clinical nature of the disease, and makes paratuberculosis a relevant socioeconomic and public health issue, justifying the descriptive review of research on the disease carried out in Latin American countries. A survey of articles, published until September 2016, on the Scopus database, PubMed, Agris, and Science Direct, about detection of the agent and the disease in Latin America, without restrictions to the date of the research was performed. The keywords were as follows: "paratuberculosis," "*Mycobacterium avium* subsp. *paratuberculosis*," "cattle," "milk," "wildlife," "goat," "ovine," "dairy," and the name of each country in English. Studies found from nine of the 20 Latin America countries, 31 related to Brazil, 17 to Argentina, 14 to Chile, eight to Colombia, six to Mexico, two to Peru, two to Venezuela, and one to Panama and to Bolivia, each. The agent was detected in cattle, goats, sheep, domesticated water buffalo, and wild animals. Microbiological culture, PCR, and ELISA were the frequent techniques. The small number of studies may result in overestimation or underestimation of the real scenario.

Keywords Paratuberculosis · PCR · ELISA · Dairy · Milk

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Introduction

Latin America is the definition of the group of countries located in America, whose native languages are of Latin origin (Spanish and Portuguese). Argentina, Brazil, Chile, Bolivia, Colombia, Ecuador Paraguay, Peru, Uruguay, and Venezuela belong to South America; Costa Rica, Cuba, El Salvador, Honduras, Nicaragua, Panama, Guatemala, and the Dominican Republic, to Central America; and Mexico, to North America, as described in Fig. 1.

Paratuberculosis or Johne's disease is a contagious chronic disease of the gastrointestinal tract that affects domestic and wild ruminants, whose etiologic agent is *Mycobacterium avium* subspecies *paratuberculosis* (MAP) (Chiodini et al. 1984; Clarke 1997; Ayele et al. 2001; Mota et al. 2010). The disease is characterized by intermittent diarrhea, reduced milk production, dehydration, and progressive weight loss (Wu et al. 2007). Besides being a weakly Gram-positive bacterium, MAP has the ability to resist an alcohol-acid discoloring staining methods, for which it is called acid-fast bacilli-resistant (AFB) (Timms et al. 2011). This is due to its cell wall composition of free lipids and polypeptides, such as micolates

Fig. 1 Map representing the Latin American countries * (neither French Guiana nor other countries are included since the language spoken is not Spanish or Portuguese). Available in: http://www.mapsofworld.com/usa/usa-maps/united-states-and-latin-america-maps.html

trehalose and phosphatidylinositol mannoside (PIM), and its glycosylated derivatives, lipomananas (LM), and lipoarabinomananas (LAM). These compounds also favor the ability to induce infection (pathogenicity) by mycobacteria (Kaur et al. 2006). Such features allow the bacterium to remain within macrophages and inhibit the formation of phagosomes, thus limiting the recognition of antigens by the cells of the immune system, which results in chronic cases of infection.

In addition to its infectious nature, the composition of MAP wall is an important factor in resistance to the environment. MAP can remain viable up to 55 weeks, under favorable conditions of humidity and temperature, and can form "spore like" structures when these become unfavorable to survival, including soil and aquatic environments (Collins 2003; Lamont et al. 2012). Research has shown that MAP can also survive high temperatures and remain viable after pasteurization (Grant et al. 2002; Carvalho et al. 2012a). Van Brandt et al. (2011) also demonstrated that rapid pasteurization is not as effective in reducing MAP levels in raw milk as the slow and turbulent flow pasteurization.

The disease was first described in Germany, when Johne and Frothingham (1895) observed AFB in the intestine of a cow with chronic granulomatous enteritis. After subsequent taxonomic changes and genomic and phenotypic studies, agent similarities with *Mycobacterium avium* complex were demonstrated. Then, Thorel et al. (1990) proposed changing the nomenclature to *Mycobacterium avium* subsp. *paratuberculosis*, which was accepted and used to this day.

Sá et al. (2013) studied risk factors for infection in cattle and found that annual higher birth rates are associated with the occurrence of the disease. According to Zare et al. (2013), the season and the age of the animals also have an effect on MAP infection. A peak of infection in animals born during the summer was observed. Besides the effective contact between cows and calves, the risk factors for infection (Hirst et al. 2004) include the annual replacement rate within the herd, number of infected cows, purchase of infected heifers, and neglected quarantine for newly acquired animals. Sanitary management and rainfall can also contribute to the onset of the disease, since modified environmental conditions can enable or hinder the spread of bacteria (Schroen et al. 2002).

The seriousness of MAP transmission and infection in dairy cattle herds is mainly explained by the subclinical nature of the disease. The animals may remain in this condition for long periods, disseminating the agent, substantially reducing the production of milk and meat (Johnson et al. 2001; Losinger 2005), resulting in the animal's disposal, and impairing the well-being of such animals. Thus, economic losses may vary considerably from country to country.

Latin America still does not have records on the amount of the actual production losses caused by paratuberculosis. However, in the USA, Ott et al. (1999) reported losses between 200 and 250 million dollars a year in herds of dairy cattle. In Australia, Bush et al. (2006) identified the disease in small ruminant flocks, with average losses above $ 13,000 per farm/year.

Furthermore, paratuberculosis also affects wild animals that can maintain and carry the bacteria between herds. Research on wild animals carried out in Spain by Marco et al. (2002) reported macroscopic and histopathological findings consistent with paratuberculosis in 62.5% of deer (deer fallow) free in nature. Diarrhea and positive results for MAP cultivation were found and confirmed by PCR in two animals. Also, Salgado et al. (2011) detected the agent in wild hares in southern Chile. In 2009, the same research group became the first to report MAP isolation in wild guanacos in the country.

Besides the economic aspect, the association of MAP with Crohn's disease (CD) is a concern. CD is a chronic inflammation of the human intestine that often affects the ileum and the colon (Crohn et al. 1932), but may compromise any segment of the digestive tract. MAP is believed to be an infectious agent related to CD, due to the clinical and histologic similarities found in patients with the disease and animals with paratuberculosis (ILSI 2004; Ormaechea et al. 2009), and the frequent isolation of MAP in samples from patients affected by CD. This indicates a public health problem for the population exposed to animals with paratuberculosis and contaminated products (Bull et al. 2003; Wagner et al. 2011).

In Europe, Nielsen and Toft (2009) investigated the reports of cattle paratuberculosis from 1990 to 2008 and found an average prevalence of 20% in these animals. However, no information about the disease in goats and sheep was reported in the researched databases.

In Latin America, approximately 33 million people work in the agricultural sector and only about eight million live in urban areas. Together, they represent 25% of the economically active population (David et al. 2000).

Latin American countries lack information about the circulating strains that affect herds, which results in trade and economic disadvantage, such as losses in production and failure to comply with the sanitary standards for exporting their products. Many countries are demanding certification of the absence of MAP for the trading of animals and animal products (Kalis et al. 2004).

Therefore, in Latin American countries, where agriculture plays an important role in the economy, attention should be paid to research and government programs focused on this disease since it possibly affects not only the economy but also public health.

Data on the prevalence of the disease in the entire Latin America have not been found. Some countries have no data about the disease at all, which justifies the gathering of the data found in each country in this article, so as to provide a broad overview of the occurrence of the disease in the region.

Although there is other review papers on the subject, there are some features that also make the present article important, complete, and up to date (Fernández-Silva et al. 2014).

The present review did not present restriction on the animal species surveyed or the dates of the researches, also including MAP research in dairy foods.

Our approach included only Latin American countries, speakers of Latin languages, and included detailed information on the socioeconomic and geographic panorama, as well as the up to date research articles.

With the broad approach, it was possible to discuss current legislation on paratuberculosis control and prophylaxis programs in different countries.

In addition, the results and techniques of each work were presented and discussed, providing an overview on the herds and the circulation of MAP strains in these countries, where there is frequent trade of animals and their products, increasing the concern with the spread of this agent.

Therefore, this review is relevant and gives a full follow-up on paratuberculosis.

Methods

We researched all studies on agent detection, regardless of the date of the publication (Fig. 2). Only articles published in indexed journals were included in the review. Those from local literature, also called "gray literature," which were not internationally indexed, were discarded. Data from government agencies were considered for the characterization of the countries.

The keywords for this survey were as follows: "Paratuberculosis," "*Mycobacterium avium* spp. *paratuberculosis*," "cattle," "wildlife," "goat," "ovine," "dairy," and the name of each country in English. The following aspects were taken into account in each article: animal species, number of animals in the study, the techniques used in the study aims, and results (Figs. 3 and 4).

Results and Discussion

We found 82 articles, by August 2016 at Scopus, PubMed, Agris, and Science Direct databases which address the detection of the agent and the extent of the disease in Latin America.

Thirty-one articles were related to Brazil, 17 to Argentina, 14 to Chile, eight to Colombia, six to Mexico, two to Peru, two to Venezuela, and one to Panama and Bolivia each. The presence of the agent was demonstrated in cattle, goats, sheep, domesticated water buffaloes, and wild animals, such as sheep, lagomorphs, and guanaco.

Table 1 presents the research works included in the review. The countries are displayed in descending order for the number of studies found in each of them.

Brazil

Brazil is the largest country in South America, with more than 8,515,767 km^2, located between latitudes 5° 16′ 19″ north and 33° 45′ 09″ south and between the meridians 34° 45′ 54″ and 73° 59′ 32″ west. Its coastline is bathed by the Atlantic Ocean and its large territory borders ten countries. Except Chile and Ecuador, all countries in South America share borders with Brazil, which is the fifth largest country in the world. This feature, associated with the tropical climate, favors the raising of cattle in pastures and allows for increased productivity strategies.

The survey on the number of animals in Brazil, conducted between 2010 and 2011, showed significant growth for buffaloes (7.8%), cattle (1.6%), sheep (1.5%), swine (0.9%), and goats (0.7%) (IBGE 2011).

According to international data provided by the United States Department of Agriculture, in the end of the first half of 2013, Brazil possessed the second largest herd cattle density in the world, which is one of the highlights of Brazilian agribusiness worldwide. Brazilian cattle is sorted into two main segments, namely, meat and milk productive chains. Besides its meat production, Brazil stands out as the sixth largest producer of milk.

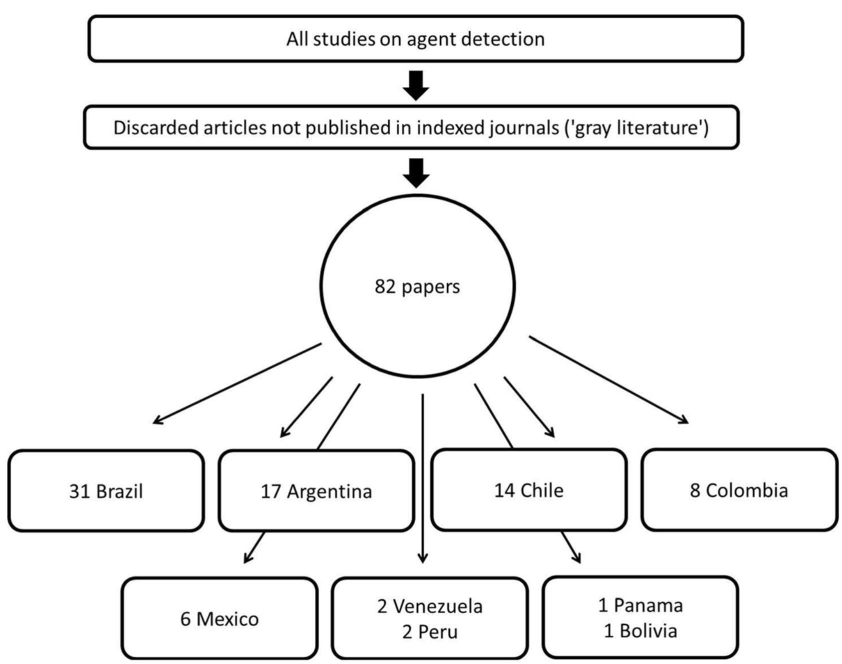

Fig. 2 Flowchart of selection of publications

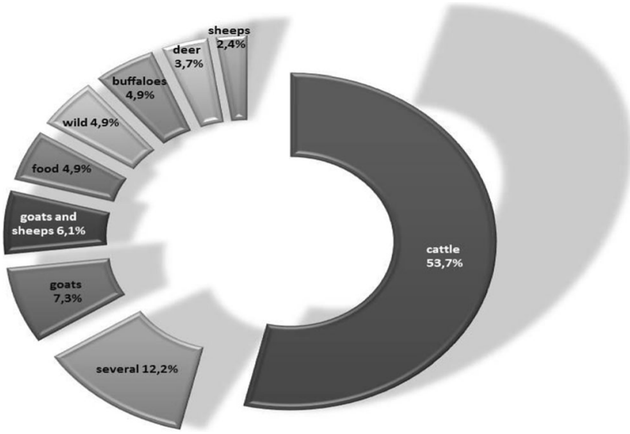

Fig. 3 Proportion of papers per studied species

As for imports, the country purchases insignificant volumes of fluid milk from Argentina and Uruguay to supply commercial demands.

In Brazil, paratuberculosis was identified in 1915 by Octavio Dupont (1915) (Table 2). However, Dacorso Filho et al. (1960) were the first to identify the disease in cattle born and raised in Brazil. Then, in 2007, Ristow et al. (2006). were the first to isolate the agent in a native dairy herd. This fact prompted research to be carried out to detect MAP by polymerase chain reaction (PCR) on samples of raw milk for the first time (Carvalho et al. 2009).

Most studies published in Brazil were done using serological methods, followed by microbiological techniques. One study evaluated the immunodiffusion test in agar gel (AGID) in 48 serum samples from 1004 animals from 45 dairy herds of the State of Rio de Janeiro. The use of AGID showed low sensitivity (57%) and specificity (92.5%). Thus, this technique is effective to confirm the positivity of suspect animals (Ferreira et al. 2002b). However, an "in-house ELISA" tested in 179 dairy cattle with paratuberculosis protoplasmic antigen (ELISA PPA) proved suitable for use in the diagnosis of suspected herds (Fig. 5) (Ferreira et al. 2002a). The combined use of molecular and serological tools, associated with macro and microscopic changes and histopathological techniques, allowed the detection of MAP in herds of water buffalo in southern Brazil in recent years. These species are reported as less susceptible to infection than cattle. Out of 203 animals, seven presented clinical pathological changes, 21 showed positive reactions by ELISA, and eight died. According to the authors, it was possible to infer that the prevalence of this herd was rated as high. The reason for this behavior is unknown, but it is suggested that the nursing behavior of these animals, associated with intensive management, can contribute to increase positivity in animals (Dalto et al. 2012).

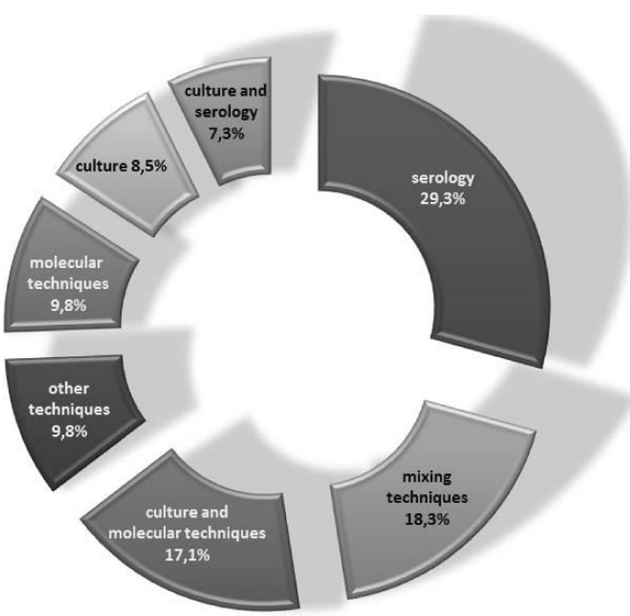

Fig. 4 Proportion of papers per utilized techniques

The methods to determine the actual reach of paratuberculosis in Brazilian states are still based on different methodologies and inaccurate results. However, studies have shown prevalence of 37.9% in 40 animals tested in São Paulo (Fonseca et al. 1999); 30% in 128 cows in the state of Rio de Janeiro (Ristow et al. 2007); 60.24% in 166 blood serum samples, in Goiânia (Acypreste et al. 2005); 45.51% in Mato Grosso do Sul (Rivera 1996) and in Espírito Santo. Costa et al. (2010) performed a serological survey in 1450 dairy cows and found positive results in 11.4% of them.

In spite of many studies on the distribution of MAP strains in the country, it was observed that the polymorphic sequence IS*900* from different strains of MAP is highly preserved and suitable for use in molecular diagnostics (Carvalho et al. 2012b). Accordingly, Faria et al. (2014) recently detected the presence of MAP DNA in 10% (3/30) of the samples of retail curd cheese in the city of Parnaíba-PI. A total of 3.3% (1/3) of these samples yielded viable cells grown in HEYM. These are outstanding findings for Brazil, since that was the first report of MAP detection in cheese in the country, even though proof of its viability in cheese was hard to achieve.

Oliveira et al. (2010) confirmed the presence of MAP in naturally infected sheep and goats, in Northeastern Brazil, by histopathology and acid-fast bacilli staining. Later, in that same region, a serologic study revealed the percentage of small ruminants infected, 44.96% of 734 serum samples from goats, and 54.08% of 392 asymptomatic sheep, from 46 different herds (Medeiros et al. 2012a).

Similarly to bovine, goat and ovine paratuberculosis has been little investigated in the country. Although the number of studies has increased in recent years, Brazil still lacks significant information about the damage in animals and the strains circulating in the country. This situation leads to economic and commercial disadvantage, since losses in production and poor sanitary standards of Brazilian animals may compromise the export of products of animal origin (Schwarz et al. 2012).

Table 1 List of the works included in the review

Country	Species	Objective of the study	Techniques used	Authors
Brazil	Goats and sheep	Reporting digestive disease diagnosed at the Veterinary Hospital	Historical research of clinical cases	Lira et al. (2013)
Brazil	Cattle, goats, sheep, etc.	Gathering epidemiological data, clinical-pathological and laboratory disease in the country	Culture, ELISA, PCR, etc.	Yamasaki et al. (2013)
Brazil	Cattle	Reporting the epidemiological aspects of MAP infection in dairy cattle of Garanhuns-PE	Serology (ELISA), investigative questionnaire	Sá et al. (2013)
Brazil	Buffaloes	Characterizing an outbreak in the southern region	Serology (ELISA), culture, PCR and immunohistochemistry	Dalto et al. (2012)
Brazil	Goats and sheep	Estimating the frequency of antibodies in animals, in Paraiba	Serology (ELISA) and culture	Medeiros et al. (2012a)
Brazil	Cattle	Performing serological investigation in herds with and without history of the disease (ELISA)	Serology	Medeiros et al. (2012b)
Brazil	Commercial milk	Investigating the presence of MAP in commercial milk samples	Culture, nested PCR and Genetic sequencing	Carvalho et al. (2012a)
Brazil	Cattle	Assessing the genetic conservation of sequences of IS*900* used for raw milk detection	PCR milk, genetic sequencing and bioinformatics (polymorphism)	Carvalho et al. (2012b)
Brazil	Cattle	Reporting pathology of three positive animals in Rio de Janeiro-RJ	serology (ELISA) and histopathology	Rodrigues et al. (2012)
Brazil	Cattle	Evaluating the efficiency of recombinant protein MAP, serological tests	Cell culture, immunofluorescence, immunohistochemistry and serology (ELISA)	Souza et al. (2011)
Brazil	Buffaloes	Investigating and characterizing paratuberculosis and its clinical and pathological changes in this species in Pernambuco	Histopathology, Ziehl-Neelsen technique in feces and PCR	Mota et al. (2010)
Brazil	Goats and sheep	Reporting the occurrence in these species in the Northeast and characterizing the clinical and pathological changes	Intradermal reaction test and histopathology	Oliveira et al. (2010)
Brazil	Bovine	Evaluating the efficiency of two recombinant proteins of *M. bovis* (MPB70 and MPB83) in serological tests to differentiate infections caused by MAP from those caused by *M. bovis*	Serology (ELISA)	Marassi et al. (2010)
Brazil	Cattle	Investigating the presence of MAP in dairy herds in Viçosa-MG	PCR and gene sequencing	Carvalho et al. (2009)
Brazil	Cattle	Reporting clinical, anatomical and pathological condition in a dairy herd of Paraíba	Histopathology and culture.	Mota et al. (2007)
Brazil	Cattle	Evaluating the effect of tuberculin on ELISA	Serology tests (ELISA) and culture	Varges et al. (2009)
Brazil	Cattle, goats, sheep, etc.	Reviewing the disease	Culture, ELISA, PCR, etc.	Lilenbaum et al. (2007)
Brazil	Cattle	Reporting the outbreak of the disease	Serology (ELISA and AGID), histopathology and culture	Ristow et al. (2007)
Brazil	Cattle	Evaluating three different formulations of? HEYM in four fecal culture protocols	Culture	Ristow et al. (2006)
Brazil	Cattle, goats, sheep, etc.	Characterizing a new locus (VNTR-MIRU) in MAP genome isolated from MAC in the South	Culture America, RFLP, PCR and Tandem Repeat	Romano et al. (2005)

Table 1 (continued)

Country	Species	Objective of the study	Techniques used	Authors
Brazil	Cattle	Standardizing ELISA for use in the country	Serology (ELISA)	Marassi et al. (2005)
Brazil	Cattle	Evaluating the AGID technique and its applicability in the field	Serology (ELISA and AGID)	Ferreira et al. (2002b)
Brazil	Cattle	Serologically evaluating the serological tests to detect the disease in herds in Rio de Janeiro	Serology (ELISA)	Ferreira et al. (2002a)
Brazil	Cattle	Describing the clinical and pathological picture of affected animals	Histopathology and culture	Driemeier et al. (1999)
Brazil	Cheese	Detecting MAP in curd cheese samples	Culture and PCR	Faria et al. (2014)
Brazil	Cattle	Making an agent of the survey conducted in a Brazilian state	ELISA	Costa et al. (2010)
Brazil	Cattle	Detecting the agent in a Brazilian state	ELISA	Laranja-da-Fonseca et al. (1999)
Brazil	Buffaloes	Reporting the detection of MAP in uterus and fetus	Histopathology and PCR	Belo-Reis et al. (2016)
Brazil	Buffaloes	Reporting farms positive for paratuberculosis	Histopathology and PCR	Farias Brito et al. (2016)
Brazil	Cattle	Determining the prevalence of MAP infection and identifying risk factors associated with herd-level prevalence	Serology	Vilar et al. (2015)
Brazil	Goats	Identifying and typing MAP	Culture, PCR and REA	Souza et al. (2016)
Argentina	Cattle	Investigating the prevalence of paratuberculosis in the country	Serology previous studies	Moreira et al. (1994)
Argentina	Goats	Reporting the MAP detection for the first time in goats	Culture from feces and milk	Ubach (1941)
Argentina	Cattle and deer	Performing RFLP Techniques to compare samples of MAP strains	RFLP	Romano et al. (2005)
Argentina	Deer	Detecting MAP in deer and performing immunohistochemical analysis of samples	Culture, staining, immunohistochemistry	Moreira et al. (1999)
Argentina	Goats and sheep	Detecting MAP in goat and sheep cheeses	Culture and Ziehl-Neelsen staining	Cirone et al. (2006)
Argentina	Cattle	Investigating the presence of MAP in pasteurized milk samples,	PCR, culture, genetic sequencing	Paolicchi et al. (2012)
Argentina	Goats	MAP isolation in goats for the first time	Culture, PCR, pathologic examination, serology	Fiorentino et al. (2012)
Argentina	Cattle	Analyzing differences, advantages and disadvantages of different types of MAP	Direct diagnosis, molecular histopathology, humoral immune response, clinical and subclinical paratuberculosis	Gilardoni et al. (2012)
Argentina	Cattle	Evaluating a protein derived from an Argentine MAP strain	Serology, γ-IFN release, statistical analysis	Gioffre et al. (2009)
Argentina	Cattle	Assessing different methods for MAP detection in cattle in the country	Serology Culture, PCR, tuberculin test,	Paolicchi et al. (2003)
Argentina	Llama	Description of a case with classic clinical signs of paratuberculosis	Ziehl-Neelsen, culture, PCR	Jorge et al. (2008)
Argentina	Cattle	Detecting the presence of MAP in food and Crohn's disease	Review	Cirone et al. (2007)
Argentina	Cattle		Serology	Fernandez et al. (2012)

Table 1 (continued)

Country	Species	Objective of the study	Techniques used	Authors
		Performing cattle IgG isotypes detection ELISA-PPA-infected cattle with Johne's disease		
Argentina	Cattle, goats and sheep	Studying MAP strain diversity	MIRU-VNTR	Gioffre et al. (2015)
Argentina	Cattle	Standardizing a diagnosis procedure to detect MAP DNA in raw cow milk samples under field conditions	Culture, ELISA and PCR	Gilardoni et al. (2016)
Argentina	Cattle	Evaluating the biological behavior of different strains of MAP on two bovine infection models	Culture, ELISA, histopathology, flow cytometry and delayed type hypersensitivity	Colavecchia et al. (2016)
Argentina	Cattle	Evaluating hyaluronic acid levels in healthy bovines and comparing them with paratuberculosis clinically infected animals	ELISA and histochemistry	Jolly et al. (2016)
Chile	Beef	Evaluating the detection power of the SMP-PCR compared to culture	Cultivation and PMS-PCR	Salgado et al. (2013)
Chile	Red Deer	Detecting MAP in flocks of red deer	Farm, PCR, smear and macroscopic analysis	Pradenas et al. (2014)
Chile	Beef	Detecting the agent in environmental samples of feces and cooling tank milk samples	PCR and culture	Kruze et al. (2013)
Chile	Beef and hares	Detecting the occurrence of the agent by comparing wild cattle and hares captured near the cattle herds	Culture and PCR	Salgado et al. (2014)
Chile	Goats, pseudorruminants, European hare	Reviewing the disease in Chilean goats	Review	Kruze et al. (2007)
Chile	Bovine	Evaluating the specificity and sensitivity of different techniques for the detection of MAP	Serology (ELISA), culture, smear, PCR	Soto et al. (2002)
Chile	Bovine	Evaluating the validity and cost of taking individual and pooled samples for the detection of MAP	Culture	van Schaik et al. (2007a)
Chile	Cattle	Conducting comparative analysis on the effectiveness of MAP detection by culture and ELISA for the validation of an ELISA test	Serology culture, PCR	van Schaik et al. (2007b)
Chile	Goats	Notifying first case with MAP isolation for dairy goats in Chile	Serology (ELISA), Culture and necropsy	Kruze et al. (2006)
Chile	Goats	Determining the accuracy of an ELISA test in MAP detection in serum and milk	Serology (ELISA) and culture	Salgado et al. (2007)
Chile	Wild guanacos	Detecting MAP infection in wildlife in a region where Johne's disease was documented	Culture, PCR, PCR with restriction endonuclease	Salgado et al. (2009)
Chile	Wild hares	Identifying the agent in wild hares where Johne's disease was documented	Histopathology, smear and culture	Salgado et al. (2011)
Chile	Cattle	Assessing risk factors that may favor coinfection of MAP and *M. bovis* in cattle at an individual level	Culture and PCR	Steuer et al. (2015)
Chile	Alpaca	Investigating the presence of MAP	Culture, PCR and MIRU-VNTR	Salgado et al. (2016)
Colombia	Several	Conducting a review on the occurrence of paratuberculosis in Colombia	Review	Restrepo et al. (2008)
Colombia	Cattle		ELISA	Benavides et al. (2015)

Table 1 (continued)

Country	Species	Objective of the study	Techniques used	Authors
		Evaluating the presence of anti-MAP antibodies in dairy farms and describing their distribution according to population characteristics		
Colombia	Cattle	Determining the seroprevalence of MAP and exploring the main risk factors associated with ELISA-positive results	ELISA	Correa-Valencia et al. (2016)
Mexico	Goats	Investigating the presence of MAP in dairy goats	ELISA	Martínez Herrera et al. (2012)
Mexico	Goats and sheep	Performing a descriptive analysis of the cases of ovine and goat paratuberculosis received for diagnosis in a laboratory	ELISA	Mendez et al. (2006)
Mexico	Sheep	Investigating the presence of MAP in sheep	Nested PCR and gel immunodiffusion agar	Morón-Cedillo et al. (2013)
Mexico	Cattle and goats	Investigating the presence of MAP in milk	Isolation, serology (ELISA), PCR	Favila-Humara et al. (2010)
Mexico	Sheep	Estimating the intra-herd correlation and design effect of MAP seropositivity and determining the association of the disease with some animal-level risk factors	ELISA	Martínez et al. (2015)
Mexico	Cattle	Determining the seroprevalence of MAP in dairy cattle and the associated risk factors	ELISA	Milián-Suazo et al. (2015)
Peru	Cattle	Identifying the presence of the agent in the region of Lima for 3 diagnostic techniques	Intradermal tuberculin Proof of avian???	Bustamante et al. (2011)
Peru	Cattle	Reporting MAP isolation in Peru for the first time	Bacilloscopy, cultivation, serology (ELISA) and PCR	Ortiz et al. (2009)
Venezuela	Cattle	Assessing the damage in limoneros Creole cattle	serology (ELISA), culture, histopathology, hematology and PCR	Sánchez-Villalobos et al. (2009)
Venezuela	Cattle	Assessing the presence of MAP in pasteurized milk	PCR and culture	Mendez et al. (2006)
Bolivia	Deer	Assessing the presence of various agents, including MAP	Immunodifusion	Deem et al. (2004)
Panama	Cattle	Comparing the use of plasma samples and serum samples to detect the agent in cattle	ELISA	Goodridge et al. (2013)

The important Brazilian position in the agricultural world market should involve the use of effective health measures in national herds and improved research on animal diseases in order to ensure the quality of products.

Argentina

Argentina, within coordinates 34° 00′S, 64° 00′ W, shares borders with Brazil, Bolivia, Paraguay, Uruguay, and Chile. It has the world's fifth largest herd, with extensive production of meat and dairy products, and the Pampa region has the largest cattle population of the country. According to the Servicio Nacional de Sanidad y Calidad Agroalimentaria (SENASA), in recent years, Argentina's livestock production has undergone major crises both in international and domestic markets due to adverse climatic events. Beef exports in Argentina fell in 2012 about 29.1% for all targets, except Chile, which showed a 4.8% growth in the imports of Argentine meat (SENASA 2012).

The main importers of meat from Argentina are Israel, Germany, and Chile. Towards the end of 2012, Argentina totaled 11,450 tons of exported meat (SENASA 2012).

In addition to meat, in 2011, Argentina produced a total of 11,600 million liters of milk and exported 2800 million of the product. The remaining 8800 l supplied the domestic demand. Argentina exports dairy products to 107 countries, including Brazil (22%), Venezuela (22%), and Algeria (13%) (IPVCA 2012).

The economic losses in the province of Buenos Aires due to paratuberculosis are estimated to be 22 million dollars for beef cattle production and 6.3 million for dairy cattle (Moreira et al. 1994; Moreira and Tosi 1995). The disease was first reported in the country in 1994, as can be seen in Table 2.

Some regions of the country showed seroprevalence of MAP ranging from 7 to 19.6% in breeding herds, according to the Instituto Nacional de Tecnología Agraria (INTA 2012). The high prevalence of the disease in Argentina and its possible relation of the causative agent of paratuberculosis with Crohn's disease suggest the need for stricter sanitary measures and testing of export and import of animals, even for those apparently healthy.

According to Paolicchi et al. (2003), besides the gold standard test for MAP detection in feces by HEYM culture, the ELISA serological test is highly sensitive to diagnose the disease. Thus, two or three tests must be conducted in the same animal to detect the subclinical or silent phase and determine the stage of the disease. This would be crucial for the starting of disease control programs and the establishment of safety standards (Paolicchi et al. 2012). This is necessary because at an early stage of the disease, in subclinical form, MAP can be eliminated through the milk, even if serological tests are negative (Paolicchi et al. 2003).

Fernandez et al. (2012) tested the performance of isotypes IgG immunoglobulins IgG1 and IgG2 in immunoassay ELISA-PPA for several cattle at different stages of the disease. However, there was difficulty in detecting antibodies specific for MAP and detecting MAP in animals with the disease at subclinical stage, when low concentrations of MAP were not detectible in the feces. Nevertheless, the study showed that the combination of IgG1 and IgG2 can improve MAP detection in cattle at different stages of the disease.

In 2012, the report on the first MAP isolation and detection from pasteurized commercial milk in Argentina was published, which indicated the potential risk of its consumption by the population (Paolicchi et al. 2012).

The first publication of MAP isolation and detection from pasteurized commercial milk in Argentina was in 2012 by using PCR and PCR-REA as molecular techniques and culture in Herold egg yolk (Fiorentino et al. 2012). Regarding the presence of MAP in cattle and goat milk, Cirone et al. (2006) highlighted the importance of maturing cheeses made with cow and goat milk without heat treatment in order to reduce contamination by MAP and other organisms and improve food sanitary quality.

There was no other official data on the progress of studies on paratuberculosis or Johne's disease, in spite of the great scientific advances in research on MAP carried out in Argentina.

Chile

Chile is located in southwestern South America, under the geographic coordinates 30 00S, 71 00W. It shares borders with Peru and Bolivia to the north and Argentina to the east, besides the Pacific and Atlantic oceans.

Its economy is one of the most important of the continent. According to the Ministry Of Agriculture Del Chile, the agricultural sector provides jobs for much of the population and accounts for a significant portion of its gross domestic product.

The cattle population in Chile is almost four million, while goats are approximately 700 thousand head (Kruze et al. 2007).

Paratuberculosis is well documented in the country, where it was first reported by Grinbergs and Caorsi (1958) in the region of Valdivia in cattle and small ruminants, including sheep (Zamora et al. 1975) in the same region. It was also described in dairy goats in 2002 and 2006 (Kruze et al. 2007).

The study by Soto et al. (2002) analyzed 14 cattle herds, totaling 250 animals, from which serum samples and feces were collected and subjected to ELISA testing, microbiological culture, direct microscopy (ZN) and confirmed by PCR. The microorganism was isolated by the cultivation technique from a total of 10 (71.4%) of the flocks and 16% of the animals, while 8% of the animals were positive, by ELISA. The number of positive animals per herd ranged between 5 and 66.7%.

The study by van Schaik et al. (2007a) investigated the presence of the agent in 600 animals from 12 Chilean cattle herds, from which feces samples were collected and submitted to microbiological culture. They showed positive results in 83% of herds and 7% of the animals. In this study, the authors also collected samples of culture in pools of five and 10 animals and found that the test for sensitivity to individual culture was 46 and 48% and did not differ statistically for the pool size. The cultivation of pooled samples is a useful tool for reducing the costs of testing, but in flocks with low load of the microorganism, it can cause a dilution effect, leading to false-negative results. Another study was conducted by van Schaik et al. (2007b) in 27 herds in southern Chile, totaling 1333 cattle, from which serum and feces were collected and submitted to microbiological culture and ELISA. The positive cultivation results were subjected to PCR to confirm the identity of the microorganism. There were 54 positive culture results, which corresponded to 4.1% of the animals tested in 37% of herds. With the use of serological testing, 86 were positive, which corresponds to 6.4% of the animals.

Salgado et al. (2013) used fecal samples from cattle and found 74.9% (263/351) of positive samples by PMS-PCR and only 12.3% (43/351) by microbiological culture.

Three studies addressing MAP detection in goat herds in Chile were analyzed. One of them was carried out by Kruze et al. (2006), which analyzed a herd of 41 animals, evaluated by ELISA and culture. Using ELISA, 22% of the animals, or nine serum samples, were positive, which was also found for five samples of milk, corresponding to 12% of the tested goats. By culture, MAP was isolated in six samples, or 14.6% of the animals. In a herd, an animal showing clinical signs consistent with paratuberculosis was euthanized and submitted to necropsy. The animal showed severe emaciation. Histopathological analysis of mesenteric lymph node and intestinal samples detected the presence of alterations consistent with the disease, including granulomas in mesenteric lymph nodes, but acid-fast bacilli were not found.

Another study on goats was performed by Salgado et al. (2007), in which samples of serum, milk, and feces of 383 goats and eight sheep were also tested by culture and ELISA. Out of the serum samples, 66 (16.8%) were positive by ELISA, while 37 (9.4%) were positive for milk samples, and 35 (9.4%), for samples that exhibited MAP in the culture medium, detected in 50% of herds. The ELISA results using serum differed from those using milk. The sensitivity of the tested serum samples was significantly higher.

Kruze et al. (2013) conducted a study using cooling tank milk samples and environmental samples from the dairy cattle facilities in the Southeast and calculated an average prevalence of 27% for environmental fecal samples and 49% for the cooling tank milk samples.

Studies with goats confirm the presence, maintenance, and circulation of the agent in the Chilean herds and highlight the lack of programs for controlling and eradicating the disease.

The study of Pradenas et al. (2014) detected the presence of the agent between herds of red deer, farmed for meat production. The study included macroscopic and microscopic findings of the disease, as well as microbiological culture and PCR.

In addition to the studies on MAP in ruminants, there are reports of its detection in wild animals in Chile. Salgado et al. (2009) presented the first report of MAP isolation in wild guanacos, with a population of 86,000 individuals that inhabited the Tierra Del Fuego island, where 501 animals were analyzed by the microbiological culture, confirmed with PCR and strains typed by PCR with restriction endonuclease, which provided the characterization of the strain in bovine, ovine, and intermediate origin. Upon cultivation, 21 (4.2%) samples were positive, all from the same genetic group C-type, typically isolated from cattle. Another important fact highlighted by the study was that all cultivated isolates came from continuous geographic areas or regions close to cattle farms.

Salgado et al. (2011) detected MAP in wild hares in the southern region of the country, where the animals are in contact with herds known to be infected by the bacterium. Animals of the species *Lepus europaeus* were captured and had their feces, lymph tissue, and ileum collected and subjected to culture, direct microscopy, and histopathology. Histologically, the tissue presented normal appearance, without any sign of inflammation. However, MAP was isolated from 48 (12.6%) tissue samples and 16 (4.2%) fecal samples. A prevalence of 14.1% of the agent was calculated in the herd. These findings indicate that European hares mainly act as vehicles of the microorganism, without developing the disease. Later, the same group collected about 50 hares in each of the two regions of dairy herds for a study. The agent was detected in hares and animal herds. The results found a statistical association between MAP-infected hares and the corresponding herds (Salgado et al. 2014).

These studies did not explain when or how these animals were infected. However, proximity to cattle herds known to be infected or potentially exposed to the regions studied, where wild animals live, and the identification of typical strains from cattle, suggests that the introduction of the agent in these populations of pseudoruminants and lagomorphs took place through contact with domestic animals.

Although the results obtained in the study of hares do not indicate the development of the disease in these animals, the absence of control programs before the confirmation of the presence of the agent in herds of cattle, sheep, and goats poses a risk to exposed wildlife, when the development of the clinical form of the disease has not been confirmed, but is likely to occur.

Colombia

Colombia, the second most populous South American country, with more than 45 million people, shares borders with the Caribbean Sea, Venezuela, Brazil, Peru, Ecuador, and Panama. Besides the continental territory located in the coordinates 4 00 N, 72 00 W north of South America, the country has two island territories, San Andrés and Measures in the Caribbean Sea, and the island of Malpelo in the Pacific.

The economy of Colombia is based on mining and agriculture. The country, a major producer of beef, was ranked at the 15th position in world production in 2003, according to the Ministerio De Agricultura Y Desarollo Rural (Espinal et al. 2005; MADR 2012). Cattle population in the country was estimated by the agency in 26.8 million head, concentrated in the regions of Meta, Antioquia, and Cordoba, where about 30% of the animals can be found (Espinal et al. 2005; MADR 2012). Almost all meat production is intended for domestic consumption, and exports account for less than 1% of the total amount, while imports account for almost 0.4% of national consumption (MADR 2012).

The country is almost self-sufficient in milk production and imported about 18 tons of milk between January and August 2012, mainly from Argentina and Chile, according to the Ministry of Agriculture. In turn, exports of milk in Colombia, according to the Ministerio de Agricultura de Colombia (November 2012), have presented a sharp decline and reached 66% in volume in 2011. Venezuela and Ecuador are the main destinations of the product. According to the same source, from January to August 2012, exports of the product reached 449 tons, which means a decrease of 9% in the volume exported over the same period in the previous year (MADR 2012).

The disease was first reported in the country in 1924, as can be seen in Table 2. Despite the outstanding national milk production, Restrepo et al. (2008) report the lack of programs to control and eradicate paratuberculosis in the country. They claim that the disease was first diagnosed in the Colombian territory, in 1924, on the farm "El Hato," in Usme. Since then, cases have been reported by the Instituto Colombiano Agropecuario (ICA) in Meta and Antiqua (Restrepo et al. 2008).

Despite the confirmed occurrence of the disease in Colombian cattle, epidemiological studies on the incidence, prevalence, and distribution of the disease are scarce, often published in local newspapers, based on isolated clinical cases and reduced samples. In addition, in spite of their relevance for the development of a control and prophylactic program, data on the immune status, genetic traits, sex, and age of the animals have not been regularly documented. According to Restrepo et al. (2008), these facts result from the absence of public policies, support, and investment in research.

One of the studies on the detection of the agent in Colombian herds, carried out by Fernandez-Silva et al. (2011a), used 307 animals from 14 herds located in the Andean region of Colombia, whose serum and stool samples were subjected to serological (ELISA), molecular (PCR), and microbiological (culture) tests. In this research, the samples were subjected to ELISA-A test, which is based on lipoarabinomannan detection. When the results were positive, the samples were subjected to other tests. Out of the 307 samples, 31 were positive for ELISA-A, which corresponds to 10% of the animals tested in 71% of herds. Out of the 31 positive results, only two were positive for the ELISA-B, which relies on the detection of anti-MAP antibody antigens. Six were positive for PCR and none for culture. The two positive results for ELISA-B were obtained from different livestock that belonged to the same owner and included traffic animals, which confirms the highly contagious nature of the disease.

Fernandez-Silva et al. (2011b) used the ELISA test, microbiological culture, PCR, and the multilocus short sequence repeat (MSSR) test, for the molecular characterization of MAP strains. Correlation between the results of the different tests was considered low in this study and in the previous study mentioned above. This study investigated 386 fecal samples, 329 serum samples from the same animals, and environmental samples, collected from the milking parlor and facilities. Tissue samples were also collected from an animal with symptoms compatible with Johne's disease, which was eventually euthanized. The cattle under study were from five herds. Six animals (1.8%) were positive by ELISA, in 40% of herds and, eight animals were positive for culture, four stool samples, two for tissue samples, and two of environmental samples. All the results obtained from culture and real-time PCR were consistent with MAP. With respect to the molecular characterization of isolates obtained from MSSR, it was found that fecal samples, environmental samples, and one of the tissue samples corresponded to a certain type of strain, while another tissue sample and the remaining environmental sample belonged to the other. It corroborates the presence, maintenance, and circulation of more than one agent strain in the herd.

Waard (2010) conducted a study using 55 cattle from the herd of the Faculty of Veterinary Medicine of Cordoba in Monteria, where the animals were tested by ELISA, which provided positive results for 25% of them.

The intradermal test was used in the analyses of Ramírez et al. (2011), combined with a retrospective study using data collected between 2000 and 2008, from 105 animals of the University Antioquia, in San Pedro de Los Milagros, where five cases compatible with the disease were found. The data analyzed included, besides the intradermal reaction test, information on the autopsy, histopathological analysis, and clinical changes. The animals presented chronic diarrhea, weakness, and melena. The necropsies showed emaciation, mucosal thickening, swelling, and congestion, besides the histopathological findings of granulomatous enteritis and lymphadenitis. The histology and presence of large amounts of resistant acid-fast bacilli (AFB) in intracellular macrophages and giant cells were observed in three animals. The analyses confirmed the occurrence of paratuberculosis in the cattle.

The authors obtained low agreement between tests in most studies. According to these studies, AFB detection by Ziehl-Neelsen has only 86% specificity and may lead to underdiagnosis due to unequal distribution and possible low bacterial load in infected animals.

Regarding ELISA, the authors also described discrepancy between the results from different kits. This was potentially the result of using different target detection tools, involving the different types of immune responses that are present at specific stages of infection or the presence of bacterial antigens. The results of the skin test with avian tuberculin obtained in the studies showed that cross-reactivity may have occurred when the animals were previously submitted to intradermal test with bovine tuberculin for checking the status of the establishment of *Mycobacterium bovis* infection, resulting in false-positive data. It is worth remembering that the positive result to the test of avian tuberculin does not specifically indicate response to MAP infection, since other mycobacteria of the *Mycobacterium avium* complex might have caused the infection, or other condition could result in a false positive as described above.

Thus, the studies described show the presence, maintenance, and circulation of MAP in flocks in Colombia. They also reveal concern for the lack of programs and investments for the control, prevention, and eradication of the disease.

Mexico

Mexico is located in southern North America, under the coordinates 23° 00 ′N, 102 00′W. It is limited to the north by the USA; to the south, by Guatemala and Belize; to the east, by the Gulf of Mexico; and to the west, by the Pacific Ocean. Its economy is the second largest in Latin America.

The livestock industry plays a significant role in Mexican economy. It is extensive and more developed in the central region of the country.

The disease was first reported in the country in 2008, as can be seen in Table 2.

Martínez Herrera et al. (2012) conducted a sero epidemiological survey on goats from five municipalities of the central region of Veracruz, through indirect ELISA. The overall prevalence of paratuberculosis in cattle was 0.6% (1/182), which shows low distribution of the agent in this Mexican region.

Méndez et al. (2009) conducted a descriptive analysis of cases of ovine and goat paratuberculosis received for diagnosis in a laboratory in Mexico. In this study, 18% of the samples analyzed (418) were seropositive.

Morón-Cedillo et al. (2013) analyzed the prevalence of MAP infection in sheep using nested-PCR and agar gel immunodiffusion. The tests were carried out in 211 asymptomatic animals. In AGID, the prevalence was 9.48% and in nested-PCR, 7.58%.

Favila-Humara et al. (2010) found MAP in milk samples from cattle and goat herds in the central region of the country. The samples from 759 cattle and 371 goats were analyzed by ELISA, culture, and PCR. Seroprevalence ranged between 8 and 24% in cattle herds and between 8.29 and 9.67% in goats; and colonies compatible with MAP were isolated in 10 samples of whole cattle milk. The DNA was detected in the tank milk from all 14 herds but not in the individual samples. It indicates that the tank and machines used for milking can be sources of contamination.

No programs for paratuberculosis control or prophylaxis were reported from Mexico in the sources.

Venezuela

Venezuela is located in northern South America under the coordinates 8 00 N, 66 00. It is limited to the north by the Caribbean Sea, to the south by Brazil and Colombia and to the west by Guyana. The country has a total area of 916,445 km^2 and land area of 882,050 km^2.

Venezuela has the 5th largest economy in Latin America, coming after Brazil, Mexico, Argentina, and Colombia. It exports mainly oil to the USA (33.6%) and Brazil (11.7%) (VENEZUELA 2014). Most animal products consumed in the country are imported from Brazil (APEX-BRASIL 2011).

There are few studies available on paratuberculosis occurrence in Venezuela; the disease was first reported in the country in 2009, as shown in Table 2. A study in the state of Zulia reported the presence of MAP in herds of Creole limonero cattle, in which serological evaluation and PCR have demonstrated the existence of infected animals with positive rates of 1.45% (3/207) and 5.19% (3/77) for samples of blood and milk, respectively (Sánchez-Villalobos et al. 2009).

In addition, a second study conducted in Venezuela aiming to grow MAP from commercial pasteurized milk samples revealed that none of the 83 samples were positive for the agent. However, in two samples from different properties, the growth of six colonies identified as *Mycobacterium bovis* was observed (Mendez et al. 2006).

The presence of positive animals in the country makes it clear that immediate action must be taken to control the disease in the national herd.

Peru

Peru is located in the western South America, with latitude and longitude 10 00 S, 76 00 W, limited to the south by Chile; to the east, by Brazil and Bolivia; and to the north, by Ecuador and Colombia, belonging to the Southern Hemisphere.

According to Milan and Ho (2014), the agricultural economic sector in Peru employs 14.5% of the population (Milan and Ho 2014). The national cattle herd has five million animals, most of which confined on small farms for meat production. According to the Instituto Nacional de Estadisticas e Informacion (INEI 2012), the livestock industry in Peru grew 3.62% between January 2011 and January 2012, an increase of 3.12% in meat production and 4.54% in milk production.

In the study carried out by Ortiz et al. (2009), the agent was first isolated in the country from a 4-year-old male cattle without any clinical symptoms. In this case, serum ELISA tests were initially conducted and positive results obtained. Then, feces were collected for culture, Ziehl-Neelsen and PCR, which also were positive for the presence of MAP.

In a study by Bustamante et al. (2011), samples from 60 cows from 3 farms were tested in the region of Lima, using two different ELISA kits, microbiological culture and intradermal tuberculin test. The animals were submitted to serologic testing and 22 presented positive results. Stool samples were collected from these 22 animals, and then processed and submitted to microbiological culture, with five positive results, confirmed by PCR. Significant agreement was observed only between the two ELISA kits. According to the author, such difference between the diagnostic methods may be due to the type of detection from each agent (the detection of cellular or humoral immune response) as discussed above.

By 2008, Peru was a country considered free of paratuberculosis, but that status was revoked when the OIE reported the detection of the agent in the country, without declaring which diagnostic method was used (Ortiz et al. 2009). Thus, such studies draw attention to the need for the presence of research on paratuberculosis in herds in that country.

Bolivia

The country is the 17th largest economy in Latin America and is located between the geographical coordinates S 65° W and shares borders with Brazil, Peru, Chile, Paraguay, and Argentina. Its economy is based on the oil industry and agriculture.

In 2004, Deem et al. published an epidemiological survey on various pathogens in gray deer (*Mazama gouazoubira*) from the Gran Chaco region of Bolivia. These agents were screened for the presence of MAP, but none of the 15 animals tested by immunodiffusion in agar gel was positive.

In spite of the negative result, the disease is known to be present in border countries, as previously described, which, together with the relevant role of agriculture for the Bolivian economy, reinforces the need for more research on paratuberculosis in animals in the country.

Panama

Panama (900 N, 80 00) holds about 1.72 million cattle. In 2008, Brazil and Panama signed a health protocol for the export of Cattle semen and embryos. In 2011, the two countries started talks on the expansion of bilateral trade in this area, due to the threat of MAP entrance in the country.

In partnership with researchers from Colombia and Venezuela, Goodridge et al. (2013) developed a study where 49% of serum samples from Gyr and Jersey cattle were positive by the ELISA test, as well as 2% of Mestizo animals; this was the first report of the disease in the country. Therefore, further studies should be conducted to determine the presence of the agent in herds.

Other countries and Overview

No research publications on MAP have been found for Cuba, Guatemala, Dominican Republic, Nicaragua, Honduras, El Salvador, Costa Rica, Paraguay, or Ecuador in the consulted sources. This is striking, since agriculture has increased or accounted for a significant part in the GDP in some of these countries. Some of them share borders with others where the agent was detected. Coupled with the intense trade of animals and products, it suggests that their flocks are also exposed to the agent.

As demonstrated in this study, animal husbandry plays a fundamental socio-economic role throughout Latin America, which highlights the importance of investigating diseases, such as paratuberculosis, because they may affect milk and meat production. The review presents the current situation of the disease, which was first described about 100 years ago (Fig. 5). Nevertheless, many countries have not started researching it despite their vast herds of ruminants or pseudoruminants.

It is observed that different groups use different techniques for agent detection, which hinders the comparison and analysis of the results for their specificity and sensitivity.

Several authors reported the absence of government investments on research or implementation of measures for the control and prevention of the disease. Nevertheless, some governments have developed some strategies, which are described in Table 2. They show that, although there is much to overcome and improve in paratuberculosis research, there is concern about the health and welfare of animals on premises, which is the first step to controlling the disease. Therefore, control and prevention programs must be implemented to ensure healthy herds for the production and trading of products considered safe for the public.

Countries such as Brazil and Argentina have carried out strong research and accumulated accurate reports on the scenario of the disease in their territories. As a result, this may affect the long-term development of strategies for the control and prevention of paratuberculosis in these and neighboring countries.

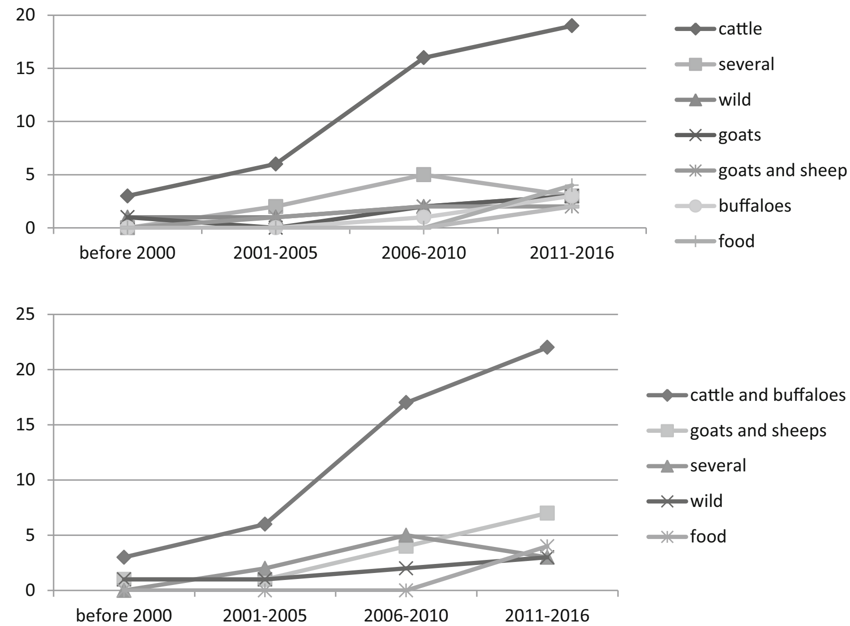

Fig. 5 Importance of paratuberculosis studies per species over the years in Latin America

Table 2 First description and measures for the control and prevention of paratuberculosis in force in Latin America

Country	First identification	Description	OIE (2014)	OIE (1996)	Normative
Brazil	1915	Beef	+	1993	QF, Te*
Argentina	1994	Beef	+	+	*, P, Q, S, TV
Chile	1958	Cattle/PR	+	+	Qf, Te
Colombia	1924		++	+	TV
Uruguay	1947	Bovine	+	+	Qf
Mexico	in 2008	Bovine	++	+	PeruTe
Venezuela	2009	Beef	+	+	*, Qi, S, sp., Te
Bolivia	–	–	±	0	–
Panama	in 2013	Bovine	–	±	Qf
Guatemala	–	–	0	0	–
Dominican Republic	–	–	0	0	–
Honduras	–		–	0	–
Nicaragua	–	–	+	+	–
El Salvador	–	–	0	–	–
Costa Rica	–	–	+	+	–
Paraguay	–	–	0	–	–
Ecuador	–	–	++	1994	Sp, TV

+: Declared at least one case;

++: Declared more than 5 cases in 2014;

+/-: Presence suspected, but rather confirm;

*: Mandatory Declaration;

QF: Quarantine border;

Qi: Quarantine for inner movements;

Q: Quarantine border and inside;

S: Sanitary Sacrifice;

Sp: partial sacrifice;

TV: Test volunteers;

Te; Follow-up.

WAHID, OIE 2015 Available in:.(http://www.oie.int/wahis_2/public/wahid.php/Wahidhome/Home)

Conclusions

Most research was conducted within Brazil, Argentina, and Chile.

Most studies used culture, ELISA, and PCR techniques. The use of different techniques may potentially change the outcome of these results making comparisons between research groups difficult.

MAP has been identified in countries that have carried out a significant amount of surveys. Although the disease has been reported in Latin America for nearly 100 years, no consolidated programs for adequate control and prevention of this disease have been either implemented nor even appropriate data collection. This leads us to infer that paratuberculosis is prevalent.

These cases suggest that the disease has enzootic characteristics in Latin America and surely and causes insidious economic losses to livestock, which is likely to worsen if this problem remains untracked.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interests.

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