Situation of bovine tuberculosis in Ecuador

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Suggested citation: Proaño-Pérez F, Benítez-Ortiz W, Portaels F, Rigouts L, Linden A. Situation of bovine tuberculosis in Ecuador. Rev Panam Salud Publica. 2011;30(3):279–86.

SYNOPSIS

Bovine tuberculosis (BTB) is a chronic and contagious disease that affects domestic animals, wildlife, and humans. Caused by Mycobacterium bovis, *BTB causes major economic losses and poses a serious constraint to international livestock trade. Moreover, in developing countries where BTB controls are lacking,* M. bovis *is a public health concern. In most developing countries, the prevalence of BTB in livestock is unknown because the information is either not reported or not available. In Ecuador, there is no national BTB control program.*

This article reviews the BTB situation in Ecuador by examining exhaustive data from tuberculin testing surveys and slaughterhouse surveillance studies conducted in 1972–2008 in a variety of the country's geographic areas. In Ecuador, several factors, including the dairy industry's expansion (preempted by the high demand for milk and its byproducts), intensified efforts to increase the cattle population, the presence of M. bovis, *and a lack of BTB controls, have caused a rise in BTB prevalence, and consequently, a growing push for the implementation of a national BTB control program.*

Key words: *Mycobacterium bovis*; zoonoses; cattle diseases; tuberculosis, bovine; communicable diseases, emerging; Ecuador.

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Bovine tuberculosis (BTB) is a chronic infectious disease caused by *Mycobacterium bovis*. This disease mainly affects cattle, but can also be found in other domestic and wild animals, and occasionally, in humans (1). The World Organization for Animal Health (OIE) considers BTB to be an important zoonotic disease with a socioeconomic and public health impact that affects the international trade of livestock and animal products (2).

The prevalence of BTB in developing countries remains largely unknown. According to a study conducted in 2006, Ecuador is among a group of Latin American countries assumed to have a relatively high prevalence of BTB, but a lack of reporting (3). Other countries in the group are Argentina, Bolivia, Brazil, Chile, Guatemala, Guyana, Haiti, and Peru. In 1998, it was estimated that for 24% of the Latin American bovine population, control measures for BTB were incomplete or inexistent (4). This absence of control represents a high risk for the rural inhabitants living in direct contact with animals (5). Of approximately 374 million cattle in Latin America and the Caribbean, 70% are held in areas where *M. bovis* infection rates among cattle exceed 1% (3).

In humans, the proportion of tuberculosis induced by *M. bovis* is relatively low compared to *M. tuberculosis*. In recent years, however, *M. bovis* tuberculosis in humans has become increasingly prevalent among human populations subjected to poverty, malnutrition, human immunodeficiency virus (HIV), and inadequate health care (6). Transmission through the consumption of unpasteurized milk and dairy products from infected cattle occurs mostly among the general public, whereas exposure through airborne infection remains highest among farmers, veterinarians, and slaughterhouse workers (6). According to a study published in 1998, *M. bovis* could be responsible for more than 2% of the total pulmonary tuberculosis (TB) cases and 9.4% of extrapulmonary forms among humans in Latin America, a considerable number. In addition, another study showed that in Argentina, 2% of human TB cases have been recorded as being caused by *M. bovis* (3).

Given the appearance of new cases in recent years, BTB in humans has been designated a reemerging disease in developed countries. Reemergence is most likely the result of increased world population, augmented by the movement of people and animals, environmental changes, crossing of the interspecies barrier, and changes in livestock production management (4, 7, 8).

The total economic losses due to BTB are underestimated because its impact on public health has not been thoroughly evaluated (9). Estimates of economic loss are limited to animal health issues and are based on weight loss, decreased milk production, lower reproduction rates, mortality, and condemnation of carcasses (10). In Argentina, the National Health and Food Safety Service (Servicio Nacional de Sanidad y Calidad Agroalimentaria) estimates that in 1995 annual losses due to BTB were approximately US$ 63 million (4).

This article aims to provide information on the current situation of BTB in Ecuador based on available data from studies of tuberculin skin-testing at farms, veterinary inspections at slaughterhouses, and laboratory-based diagnoses. The data presented in this article were obtained from the college libraries serving schools of veterinary medicine throughout the country. Most of the surveys were a component of veterinary students' theses. In Ecuador, there is only one research group working on BTB, which explains the limited number of published studies.

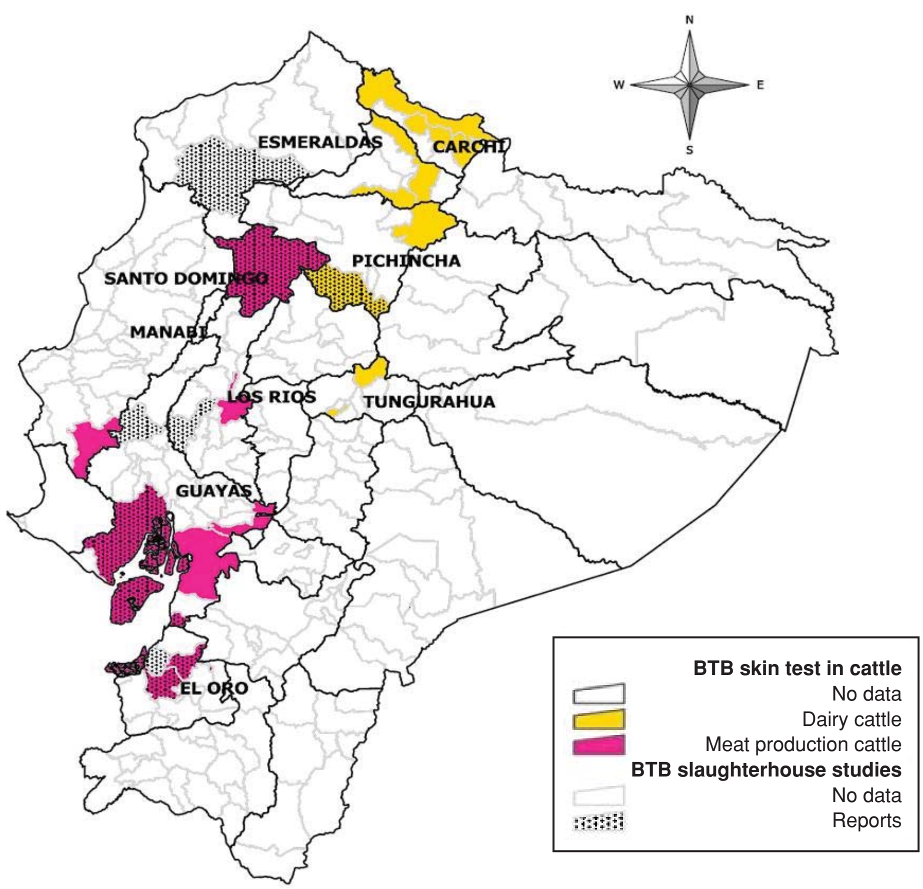
BTB PREVALENCE

BTB cases in Ecuador are not documented nor quantified clearly for several reasons: lack of proper recording of positive cases, limited use of diagnostic tests, and insufficient veterinary inspection in most slaughterhouses, but mainly because BTB is not a notifiable disease. Furthermore, it is not unlikely that in Ecuador, as may be the case in other countries, BTB is not reported due to a lack of trust between farmers and health officials (5). Currently, control measures related to relocation and transportation of animals focus solely on Foot and Mouth Disease. Furthermore, results of veterinary inspection are not recorded properly in slaughterhouses, jeopardizing the "traceability" of positive BTB cases observed during these inspections.

BTB prevalence can be influenced by several factors at the individual, herd, provincial, or country level (11). For instance, livestock husbandry varies by herd size, farm size, and type of cattle industry, i.e., for dairy or meat production. Factors such as these can affect BTB disease occurrence by increasing or decreasing close contact among animals. In Ecuador, the cattle population is not equally distributed, for example, the provinces of Azuay and Pichincha have dense livestock populations predominantly focused on dairy production, while Santo Domingo and Manabí provinces have important meat industries (12). This variation of distribution also impacts BTB occurrence.

The scarce information that is available in Ecuador is mostly based on tuberculin skin-testing performed by students at the schools of veterinary medicine within the various universities of Ecuador (Figure 1).

FIGURE 1. Studies conducted using tuberculin skin tests and veterinary inspections to determine prevalence of bovine tuberculosis (BTB), Ecuador, 1972–2008



Tuberculin skin test surveys

The sensitivity of skin testing can be affected by the potency and dose of tuberculin administered, the post-infection interval, desensitization, deliberate interference, postpartum immunosuppression, variation in the interpretation by the observer, and contact with environmental non-tuberculous mycobacteria (NTM) (13). Surveys performed in Ecuador using the single and comparative intradermal tuberculin test (SITT and CITT, respectively) have demonstrated a variable prevalence of BTB. Briefly, the tuberculin skin test is based on the use of bovine purified protein derivative AN5 strain (PPD-B) 20 000 IU/mL and avian purified protein derivative D4 ER strain (PPD-A) 25 000 IU/mL; it can be applied in the caudal fold of the tail (SITT) or in the middle third of the neck (CITT); and the thicknesses of the skin is measured with calipers 72 hours before and after the injection of 0.1 mL PPD-A and PPD-B antigens. The interpretation is based on the reaction observed (14, 15). In most of the studies performed in Ecuador, the PPD antigens used were not reported.

Table 1 presents an overview of the tuberculin-testing surveys conducted in dairy cattle in Ecuador (16–21). In 1977, the first survey detected a low (0.3%) prevalence among dairy cattle in the Tungurahua province located in the middle of the country (16). A second study conducted in 2003 in the same area showed an increased prevalence of 1.2% (17). In both studies, SITT was applied in all animals, and CITT was used to confirm all positive and suspected cases detected. Data on the herd size and origin of the PPD reagents were not presented in these studies.

In contrast, in the province of Imbabura, a survey conducted in 2001 showed a high prevalence of BTB (7.3%) (18). However, 2 years later, it showed a lower prevalence (2.4%) (19). In the province of Carchi, located north of the Imbabura province at the border with Colombia, the prevalence observed in 2001 (2.1%) was comparable to that of 2002 (1.7%) (18, 20). In general, the prevalences found in Imbabura and Carchi were higher than in Tungurahua. This was probably due to the smaller cattle population and lower animal density of Tungurahua. Plus, Tungurahua is an area more focused on agriculture than animal production (12).

The majority of the surveys, however, were performed in the province of Pichincha, specifically in the cantons of Mejía and Cayambe, the two most important dairy areas, located near the capital city, Quito. In 2001, a prevalence of 2.8% was observed in the Cayambe canton (18). This finding was in sharp contrast to a prevalence of 0.5% reported a year later (21). Worth noting is that the first study sampled only two farms; therefore, the BTB prevalence data is questionable.

Studies performed in the Mejía canton showed a high occurrence of the disease in dairy cattle. In 2002, a study (22) observed 4.9% skin reactors, which was confirmed by the prevalence of 3.9% found by another survey applied in the same area, but to different herds (14). The two studies used similar diagnostic methods, but sampling procedures differed. In the latter study, 22 cattle were randomly selected per herd from farms that were small (1–25 cattle), medium (25–70 cattle), and large (> 70 cattle). The diagnostic test used was CZV Bovine Tuberculin PPD® (CZ Veterinaria S.A., Porriño, Spain). The difference found related to herd size was highly significant: 7.9% in large herds; 3.4% in medium; and surprisingly, only 0.3% in small herds (14). Recent information from CITT analysis, using Bovituber® PPD (Synbiotics Corporation, a subsidiary of Pfizer Incorporated, Lyon, France) in 20 dairy herds in the Mejía canton showed an annual incidence of 1.7%, with a true prevalence at 7.1%. Herd size was identified as a main risk, as were age ($P = 0.03$), contact with other animal species ($P < 0.01$), and introducing new animals into the herd ($P = 0.04$) (15).

The expansion of the dairy industry in Ecuador—resulting from a growing population and its high demand for milk and by-products—meant closer

TABLE 1. Apparent prevalence of bovine tuberculosis in dairy cattle according to available studies, Ecuador, 1977–2008

Reference	Year	Location: Province	Location: Canton	Test used	Herd size[a]	No. of Herds	Positive cattle/ No. of animals	(%)
Acosta & Parreño (16)	1977	Tungurahua	Píllaro	SITT[b] & CITT[c]	NA[d]	20	7/2 132	0.33
Andino-Ashqui (18)	2001	Pichincha	Cayambe	SITT & CITT	Large	2	5/178	2.81
		Imbabura	Otavalo		Large	1	24/329	7.29
		Carchi	Espejo		Large	2	11/516	2.13
Salazar & Cevallos (21)	2002	Pichincha	Cayambe	SITT & CITT	NA	26	14/3 006	0.47
Cano & Chulde (22)	2002	Pichincha	Mejía	SITT & CITT	Large	13	152/3 089	4.92
Burbano & Léon (20)	2002	Carchi	Espejo, Tulcán Montufar, Huaca	SITT & CITT	NA	NA	52/3 011	1.73
Bedón & Verdesoto (19)	2003	Imbabura	Ibarra, Otavalo	SITT & CITT	Large	13	73/3 005	2.43
Alemán, et al. (17)	2003	Tungurahua	Píllaro, Mocha	SITT & CITT	NA	24	49/4 012	1.22
Proaño-Pérez, et al. (14)	2006	Pichincha	Mejía	SITT & CITT	Large	15	26/327	7.95
Proaño-Pérez, et al. (15)	2007	Pichincha	Mejía	CITT	Large	13	142/1 644	8.63
Proaño-Pérez, et al. (15)	2008	Pichincha	Mejía	CITT	Large	13	122/1 446	8.43

[a] > 70 bovines = large.
[b] Simple intradermal tuberculin test.
[c] Comparative intradermal tuberculin test.
[d] Not available.

contact among animals. This increased the risk of transmitting *M. bovis* bacilli (23).

Breed-related differences have been reported (1), with BTB infecting a higher proportion of dairy breeds (*Bos taurus*), than indigenous zebu cattle (*Bos indicus*) and crossbred beef cattle. Additionally, the use of the European breeds (e.g., the Holstein Friesian) to improve milk production through artificial insemination, resulted in higher BTB susceptibility (24), indirectly increasing the probability of BTB infections. Beef cattle husbandry systems differ from dairy management and have a decreased risk of infection due to less contact between animals (25). Meat production farms in Ecuador often have expansive pastures and most are located in tropical areas.

Table 2 summarizes all available studies conducted on beef cattle in Ecuador (26–36). All surveys showed a low number of skin reactors, except for two studies in the province of Guayas that showed prevalences of 3.4% and 5.6%. This high percentage can be attributed to the fact that in both studies only SITT was applied and positive reactors were not confirmed by CITT. Some of the reactions, therefore, could have been caused by contact with environmental NTM, especially in young cattle (13, 37).

Veterinary inspection

In geographic areas with high BTB, prevalence rates can be estimated by the proportion of macroscopic tuberculous lesions detected during post-mortem examination (followed by the rejection of carcasses and viscera from these animals), if a reliable system exists (9). Indeed, programs based on slaughterhouse surveillance are only effective when they use a reliable traceability system for tracing-back to herd of origin. The distribution and development of lesions depend on the route of transmission (38), and location can vary, although most often they are found in thoracic lymph nodes due to infection via the respiratory route (39). Therefore, exhaustive veterinary control needs to be established to identify affected animals, i.e., palpation and inspection of lungs, liver, spleen, kidney, mammary gland, and associated lymph nodes (39). Vigilance is recommended, however, since not all infected cattle exhibit gross lesions. On the other hand, detailed meat inspection allows the identification of lesions in apparently healthy animals, which increases the number of detected animals and avoids the consumption of BTB-infected cattle (40).

Although veterinary inspection at slaughterhouses potentially constitutes a good method for identifying the presence of TB, it is not routinely implemented in Ecuador and only a few studies on the topic have been published. Those 14 studies are shown in Table 3 (40–52). The studies that took place in 1972–2003 were conducted in the provinces located in the tropical areas where meat production is the priority; later studies were performed mainly on dairy cattle in the highlands. The first study, conducted in 1972, entailed veterinary inspection at the slaughterhouse of Guayaquil to identify pigs with BTB (41). A low prevalence of 0.2% was found. More recently, a high proportion of affected dairy cattle were observed in 2007 (2.3%) and 2008 (2.2%) in the highlands of Ecuador, specifically the Mejía canton of the Pichincha province (40). The study applied various laboratory-based diagnostic methods, in addition to the macroscopic investigation. The presence of *M. bovis* was confirmed (40).

In Ecuador's dairy areas, 90% of the cattle in the highlands are Holstein Friesian, whereas in the tropical areas, the main breeds used for milk production are Jersey, Brown Swiss, and crossbreeds. The differences in BTB prevalence among cattle breeds and geographic areas present in Ecuador, were also found in the slaughterhouses of Argentina (9), Brazil (53, 54), and Mexico (55, 56).

TABLE 2. Apparent prevalence of bovine tuberculosis in meat production cattle according to available studies, Ecuador, 1977–2004

Reference	Year	Location: Province	Location: Canton	Test used	Herd size[a]	No. of Herds	Positive cattle/ No. of animals	(%)
Cañizares (26)	1977	Guayas	Guayaquil	SITT[b]	NA[c]	NA	33/975	3.38
Maretti (27)	1981	Galápagos	San Cristóbal	SITT	NA	NA	0/1 000	0.00
Lojan (28)	1982	El Oro	Santa Rosa	SITT	NA	NA	4/1 465	0.27
Aguirre (29)	1984	El Oro	Pasaje	SITT	NA	NA	0/500	0.00
Torres, et al. (30)	1996	Santo Domingo	Santo Domingo	SITT	Large	1	21/4 888	0.43
Gutierrez (31)	1997	Guayas	El Triunfo	SITT	NA	NA	0/300	0.00
Muñoz (32)	1998	Los Ríos	Ventanas	SITT	NA	NA	0/320	0.00
Villamar (33)	2000	Manabí	Paján	SITT	NA	NA	0/300	0.00
Moncada (34)	2003	Guayas	Naranjal	SITT	NA	NA	14/250	5.60
Avellan (35)	2003	Guayas	Bucay	SITT	NA	NA	2/200	1.00
Arevalo & Zamora (36)	2004	Santo Domingo	Santo Domingo	SITT & CITT[d]	Large	37	20/4 029	0.50

[a] > 70 bovines = large.
[b] Simple intradermal tuberculin test.
[c] Not available.
[d] Comparative intradermal tuberculin test.

TABLE 3. Veterinary inspection performed on dairy and meat production animals to identify bovine tuberculosis in slaughtered animals, Ecuador, 1972–2008

Reference	Year	Location		Species slaughtered	Positive cattle/ No. of animals	%
		Province	Canton			
Villacis (41)	1972	Guayas	Guayaquil	Porcine	19/10 739	0.18
Mata (42)	1973	Guayas	Guayaquil	Bovine	16/3 425	0.47
Cruz (43)	1985	El Oro	Machala	Porcine	0/1 500	0.00
Haz (44)	1987	Los Ríos	Vinces	Porcine	1/6 420	0.02
Cueto & Suárez (45)	1993	Guayas	Guayaquil	Bovine	28/23 029	0.12
Andrade (46)	2000	Guayas	Guayaquil	Caprine	2/550	0.36
Coloma (47)	2000	Santo Domingo	Santo Domingo	Bovine	6/2 778	0.21
Villón (48)	2002	Guayas	Guayaquil	Bovine	80/4 200	1.90
Torres (49)	2002	El Oro	Pasaje	Bovine	0/1 395	0.00
Jaramillo (50)	2002	El Oro	Santa Rosa	Bovine	0/1 047	0.00
Jauregui (51)	2003	Guayas	Colimes	Bovine	0/283	0.00
Mera (52)	2003	Esmeraldas	Quinindé	Bovine	0/400	0.00
Proaño-Pérez, et al. (40)	2007	Pichincha	Mejía	Bovine	16/687	2.33
Proaño-Pérez, et al. (40)	2008	Pichincha	Mejía	Bovine	17/703	2.24

Laboratory diagnosis

Laboratory-based techniques are important for improving diagnosis of mycobacteria and identifying the species. In the slaughterhouse survey in the Mejía canton, all positive cultures obtained from tissue samples of tuberculous-like lesions were identified (40). Apart from *M. bovis*, NTM were also identified, i.e., *M. gordonae*, *M. szulgai*, *M. celatum*, and *M. avium-intracellulare-scrofulaceum*; however their clinical relevance was not further investigated. In addition, polymerase chain reaction (PCR) based on 16S rRNA (ribosomal ribonucleic acid) confirmed the presence of *M. bovis* and NTM in lungs and lymph nodes (14).

DNA-fingerprinting analysis allowed identifying different *M. bovis* strains. All *M. bovis* isolates from the Mejía canton surveys displayed the same spoligotype (SB0980) (40). The homogeneity of the isolates found in this study could reflect a short timeframe of events. *M. bovis* spoligotypes have been reported to change *in vitro* in approximately 60 years (57), which could suggest that BTB was introduced into this dairy area together with new, European cattle breeds in the mid-Twentieth century.

ZOONOTIC TB

M. bovis infection in humans can occur through inhalation of infectious droplets from a live or slaughtered animal or by consumption of unpasteurized dairy or meat products from infected animals (58, 59). People working in animal husbandry, slaughterhouse workers, veterinarians, and people in close contact with possibly-infected animals are at a higher risk for *M. bovis* infection (60). In Argentina, a 2.4% prevalence of zoonotic TB has been reported, with a high association with type of work performed (9). Lack of hygiene, existence of informal trade, absence of veterinary inspection, ignorance of the disease, and deficient use of gloves have been reported as risk factors among slaughterhouse workers (61).

In Ecuador, human cases of TB detected in public and private hospitals are reported to the Ministry of Public Health, which is responsible for the human TB control program and provides free treatment. In 2009, the Ministry of Public Health reported 3 317 microscopy-positive new cases of pulmonary TB, 584 cases of extra-pulmonary TB, and 613 deaths caused by the disease nationwide (62). According to the World Health Organization (WHO), Ecuador reported 4 703 cases of TB in 2009 (63).

The national reference laboratory, "Leopoldo Izquieta Pérez Institute" (LIP), (Guayaquil, Ecuador) identified only two *M. bovis* isolates based on their growth and/or morphological characteristics (in 1998–2005): one from the lymph node of a girl 1 year of age, and the other from a pulmonary specimen of a boy 3 years of age (64). However, it is important to take into account that *M. bovis* requires special conditions to grow *in vitro*. The appropriate medium to facilitate growth of the bacilli (65) should contain sodium pyruvate, but no glycerol, e.g., Stonebrink medium. The latter medium is not routinely used in the LIP laboratory. Secondly, a number of human *M. bovis* infections might be misdiagnosed because the procedure required for differentiating between *M. bovis* and the other members of the *M. tuberculosis*-complex is not routinely performed.

In 2007, a study was conducted on 157 farm and slaughterhouse workers from the Mejía canton to evaluate TB prevalence by tuberculin skin testing (TST). A positive reaction was seen in 29%. In addition, the risk factors associated with disease transmission among this population were studied. A significant association was documented between TST positivity and masculine gender ($P = 0.02$; odds ratio [OR] = 2.5) and consumption of raw milk ($P < 0.00$) or cheese made by hand/homemade ($P = 0.003$) (66). These findings clearly show that cultural habits play a major role in risk behavior; consumption of raw milk is considered healthier and is widespread among this population group.

ECONOMIC LOSSES FROM BTB

The national economic losses due to BTB cannot be accurately calculated because standardized data is lacking, and the data that does exist is simply an estimate of BTB prevalence. However, the economic losses in the Mejía canton are estimated at approximately US$ 460 000 per year. This estimation is based on the true prevalence determined in 2008 by CITT (15) and official data on the cattle population for this canton: approximately 55 000 head of cattle distributed among 2 722 herds (12). Three important factors were considered in estimating economic losses caused by affected cattle: decreased milk production (13%), weight loss (36%), and decreased reproductive rate (12%) (10). Nevertheless, the condemnation of carcasses was not taken into account for this calculation because the BTB-suspected cattle were not always entirely destroyed due to a lack of sanitary controls in some slaughterhouses.

BTB CONTROL PROGRAM

Today, the quality of dairy products is a high priority for the global dairy industry, as it is for Ecuador's. In Ecuador, the Ministry of Agriculture and Livestock's food safety department focuses on the quality of animal products. The private dairy sector pays more to dairy farmers who have earned a health certificate, awarded by the Ministry of Agriculture and Livestock, declaring their herd to be free of brucellosis and BTB. In theory, this status should be granted only after two consecutive negative results, meaning disease is not found among the herd, at two 6-month controls. In addition, the certification should be granted only by the Ministry of Agriculture and Livestock. However, this is not always the case in practice. Private laboratories offer tuberculin testing for cattle, but the tests are generally not administered by qualified veterinarians. Plus, the quality of PPD is not tested because there is no reference laboratory for animal diseases.

In general, BTB control programs are based on the early diagnosis and rapid elimination of positive CITT reactors on farms and at trade. Complementary strategies are recommended, i.e., epidemiological surveillance, proper veterinary supervision at slaughterhouses and cattle markets, and adequate control of cattle movement (67). In Spain, such a policy has been implemented since 1965, resulting in reduced BTB prevalence among cattle (68).

In Ecuador, there is no national BTB control program implemented yet. A national policy should be established with an obligatory CITT and culling of positive reactors. However, the implementation of such a national program has economic and logistic limitations. The total cost of a control program cannot be financed by the government alone; it should be shared with the private sector. Financial support should cover all related expenses, i.e., education and public awareness, incentives for farmers to improve the health status of their herds (through the price of the milk), regular CITT, compensation for culling, surveillance monitoring, and research.

NEXT STEPS

In conclusion, the data presented by this article confirm the presence of BTB in beef and dairy cattle in Ecuador, and justify the implementation of a national health policy to control the disease. A national control program is urgently needed to avoid the spread of BTB, and is an important step toward promoting international trade of animals and their products. Moreover, these measures would reduce the zoonotic impact of the disease among the population, especially in high-risk groups living in BTB-prevalent areas of the country. The situation in Ecuador may be similar to that of other countries in the Region of the Americas; thus the information present here could be used to help plan control and eradication programs elsewhere.

Acknowledgements. The authors gratefully acknowledge the financial support provided by the Commission Universitaire pour le Développement, University of Liege (Liege, Belgium), Project PIC (Programme interuniversitaire ciblé).

SINOPSIS

Situación de la tuberculosis bovina en el Ecuador

La tuberculosis bovina es una enfermedad contagiosa crónica que afecta a los animales domésticos, los animales salvajes y los seres humanos. Es producida por Mycobacterium bovis; *causa grandes pérdidas económicas y plantea una grave limitación para el comercio ganadero internacional. Por otro lado, en los países en desarrollo donde no hay controles de la tuberculosis bovina, la infección por* M. bovis *representa un problema de salud pública. En la mayoría de los países en desarrollo, la prevalencia de tuberculosis en el ganado se desconoce porque la información no se comunica o no se consigue. En el Ecuador no hay un programa nacional de control de la tuberculosis bovina.*

En este artículo se revisa la situación de la tuberculosis bovina en el Ecuador, sobre la base de un análisis de los datos exhaustivos obtenidos de encuestas sobre pruebas de tuberculina y de los estudios de vigilancia llevados a cabo en mataderos entre 1972 y 2008 en varias zonas geográficas del país. En el Ecuador varios factores, como el crecimiento de la industria láctea (impulsado por la alta demanda de leche y sus derivados), los intensos esfuerzos para aumentar la población bovina, la presencia de M. bovis *y la falta de con-*

troles de la tuberculosis bovina, han ocasionado un aumento de la prevalencia de esta y, en consecuencia, representan una motivación creciente para llevar a cabo un programa nacional de control de la tuberculosis bovina.

Palabras clave: *Mycobacterium bovis*; zoonosis; enfermedades de los bovinos; tuberculosis bovina; enfermedades transmisibles emergentes; Ecuador.

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Manuscript received on 24 January 2011. Revised version accepted for publication on 17 April 2011.