ELSEVIER

Veterinary Microbiology 90 (2002) 31–38

veterinary microbiology

www.elsevier.com/locate/vetmic

Brucellosis in Central America

Edgardo Moreno*

Tropical Disease Research Program, Veterinary School, National University, Apartado 304-3000, Heredia, Costa Rica

Abstract

Brucellosis is a disease of domestic animals and humans in Central America (CA). Bovine and swine brucellosis caused by *Brucella abortus* and *Brucella suis*, respectively, have been identified in all CA countries, while ovine and caprine brucellosis caused by *Brucella melitensis* has been detected in Guatemala. The prevalence of bovine brucellosis is estimated between 4 and 8%, with higher prevalence in dairy herds, with losses calculated at US$ 25 million per year. National Control Programs based in calf vaccination and removal of the reactors have had little impact in the control of brucellosis in CA. In a region where experimentation with new vaccines is not affordable, unrestricted adult vaccination by the conjunctival route with S19 is recommended. This strategy is expected to reduce the prevalence and density of the bacteria to numbers where ''clean'' vaccination would be possible. Thereafter, serological identification and elimination of the reactors could be initiated under more favorable conditions of herd infection.

Keywords: Brucellosis; Central America; Guatemala; Belize; Honduras; El Salvador; Nicaragua; Costa Rica; Panamá

1. Introduction

Central America (CA) composed by Guatemala, Belize, Honduras, El Salvador, Nicaragua, Costa Rica and Panamá, spans a thin region of 523,000 km^2 that joins the two continental masses of North and South America. Despite of sharing the same geographical area, major political, economical and historical differences demarcate the various countries (Table 1). With the exception of Costa Rica and Panamá, where conditions are less dramatic, the other CA countries must struggle against poor budgets and limited laboratory facilities for the diagnosis and control of infectious diseases (Arellano et al., 1981). This reality, coupled with constant social conflicts and natural

* Tel.: +506-2380761; fax: +506-2381298.
E-mail address: emoreno@ns.medvet.una.ac.cr (E. Moreno).

0378-1135/02/$ – see front matter
PII: S0378-1135(02)00242-0

Table 1
Comparison of the social and economical development of the CA countries

Country	Illiteracy rate (%)	Children life expectancy[a]	GIP per capita	Development index among 162 countries	Average GIP 1997–2000 (%)	Education investment (percentage of GIP)
Costa Rica	4.8	9.0	8.9	41	6.5	5.9
Panamá	8.9	8.0	5.9	52	3.6	5.0
Belize	15.4	6.0	5.0	54	5.0	2.5
El Salvador	23.0	6.0	4.3	95	3.2	2.5
Nicaragua	36.6	3.0	2.3	106	5.5	4.0
Guatemala	33.4	4.0	3.7	108	4.1	1.7
Honduras	29.3	5.0	2.3	107	2.7	3.0

For comparison purposes, Costa Rica indexes are similar to those of Chile but above Mexico and Brazil. Source: UNESCO, annual statistics 1997–2000.

[a] Expressed as (1000 − children survival up to 5 years of age per 1000 live births)/10.

disasters has contributed to damage or the elimination of the few existing resources (www.fao.org/sd/wpdirect/wpan0042.htm). These circumstances have also promoted the exodus of the best-trained individuals who are drawn by better opportunities in the northern countries. Consequently, investigations on brucellosis in CA are discontinuous and not rigorously systematic (http://www.oie.int). The published materials related to this topic are scarce, being the principal sources the yearly reports of Animal and Health Ministries and of the Veterinary Schools. With this limitation in mind, I will attempt to summarize the problem of brucellosis in CA.

2. Generalities

CA comprises a community of 36 million inhabitants with a labor active population of 12 million and unemployment rate close to 15%. Despite this, signs of slow progress are foreseen (Table 1). The economy of CA is very fragile, most of it depending on crops, animal husbandry and tourism. In the last few years Costa Rica has developed an additional source of income based upon the manufacturing of computer hardware. Panamá has increased its economy thanks to the stabilization of the social situation and trade through the inter-oceanic canal, as well as the National ports. Approximately 50% of the active population are dedicated to animal husbandry and agriculture. The former mentioned industry is among the 10 most relevant sources of income to the CA's economy and a source for permanent jobs (http://www.iicanet.org). This industry is also important from the social perspective since it avoids demographic movement from rural to urban areas. Most of the animals transported from farms to other areas for marketing and slaughtering are seldom inspected, except when passing from one country to another. In this case, the animals require a health certificate. Slaughterhouses are rarely inspected for brucellosis. CA is free from foot and mouth disease; therefore, imported animals come from vaccinated herds purchased in the North American countries and from countries within the region. The economical losses due to animal brucellosis in CA, have

been estimated to be US$ 25 million per year. For a region with low national incomes, this lost is very significant.

3. *Brucella* natural hosts

Among the *Brucella* natural hosts in CA, bovines are by far the most relevant, followed by swine, ovines, canines and caprines (Table 2). The bovine population has steadily decreased during the last 15 years. For instance, in 1985 the number of bovines in Costa Rica was 2.3 million, just slightly lower than the number of inhabitants at that time. Similar situations have been recorded in other CA countries. The reasons are diverse, but lower meat prices and constrains in the exportation of bovines and their products are two important factors. The management of beef and double purpose cattle (beef and dairy) is extensive and herds are mainly composed of cebuine breeds. Beef herds are seldom larger that 2500 animals. Most of the cattle for beef industry are located in the lowlands along the Pacific and Atlantic regions, while the dairy farms are located in the inter-montane regions and the highlands. In contrast, the management of dairy animals (constituted by European breeds) is intensive. Dairy herds usually range between 5 and no more than 300 cows, however, due to difference in management, dairy farms have more bovine density than beef farms and consequently, more brucellosis. The pork meat industry in CA is primarily devoted to local consumption. Large swine herds are in the hands of a few owners. With the exception of Costa Rica, small groups of domestic pigs (from 2 to 10) roaming freely around the houses are commonly seen in the rural areas. Ovines and caprines are concentrated in small herds in Guatemala and to a less extent in Honduras, being of minimal importance in the other CA countries. Canines are very popular in CA as domestic pets. The number of dogs is not known, but in rural areas it is common to have more than one dog per family. In the urban areas, the number of dogs per family is lower, however, there are a large number of dogs roaming freely in the streets. In dairy farms, dogs are commonly fed with non-pasteurized milk and carcasses, including aborted fetuses.

Table 2
Number of domestic livestock in the Central American countries[a]

Country	Bovines	Swine	Ovines	Caprines
Guatemala	2,291,449	889,000	551,087	77,800
Belize	60,000	18,662	2,847	1,300
Honduras	2,077,460	479,434	13,145	28,000
El Salvador	1,250,000	260,000	6,000	15,300
Nicaragua	2,992,237	277,451	7,392	6,400
Costa Rica	1,493,789	222,135	7,863	1,600
Panamá	1,399,487	256,361	636	5,200
Total	11,564,422	2,403,043	588,970	135,600

[a] From OIRSA: http://ns1.oirsa.org.sv/Default-01.htm.

4. *Brucella* species and diagnosis

The identified *Brucella* species in CA follow the distribution and proportion of their natural hosts. The low number of isolates reported corresponds to the degree of laboratory development in the CA countries. It is understandable that most isolates have been performed in research facilities and in clinical laboratories devoted to the diagnosis of human diseases (Sequeira et al., 1984). *Brucella abortus* biotype 1 and 2 are the only identified biotypes in CA and the most common isolated strains, mainly in bovines, humans and sporadically in dogs and horses. *Brucella suis* has been isolated from swine and humans in all CA countries. *Brucella melitensis* has been isolated from ovines and humans in Guatemala and suspected in Panamá. *B. canis* has been isolated from dogs in Costa Rica. Surveys of 80% of the ovine and caprine population in El Salvador and Costa Rica did not reveal antibodies against *Brucella*, suggesting the absence of *B. melitensis* in these countries. Restricted surveys have failed to reveal antibodies against *Brucella* in wild mammals.

Plate agglutination and rose Bengal are commonly used as screening tests and very often the only assays available in rural areas. Rivanol and 2-mercaptoethanol tests are commonly used as the only confirmatory assays. Due to its relative complexity, complement fixation has been used sporadically. Competitive ELISA has received great deal of attention as confirmatory test in CA (Gall et al., 1998). However, only a few laboratories, mainly located in the capital cities, are prepared to perform this analysis. Complement fixation and competitive ELISA are commonly reserved for trading and exportation purposes. Human infections are primarily diagnosed by plate agglutination with antigen from human febrile illness (Campos et al., 1984; Pérez-Roman et al., 1984). Other tests, such as RID, PCR and specialized immunoenzymatic assays or immunodiagnosis of tissue samples are performed in research units (Gall et al., 1998; Rojas et al., 2001).

5. Brucellosis in domestic animals and humans

Based on limited serological surveys performed during the last 10 years, the estimated prevalence of bovine brucellosis in CA corresponds from 4 to 8%, and a rate of herd infection (mainly dairy herds) is from 10 to 25%. El Salvador seems to be the country with less bovine brucellosis (close to 1% prevalence), while Guatemala and Costa Rica seem to possess the highest prevalence; although, this may be the result of more efficient diagnosis performed in these countries. Most of the infected bovines are concentrated in the pre-mountain and high lands, were dairy herds are located. Even though the number of bovines per herd is larger in farms located in the lowlands, the *Brucella* infection prevalence is moderate. It is known that the risk for transmission is reduced in extensive type of management where lower density of bovines exists and the life span of these animals is shorter. In contrast, the intensive type of management that favors close contacts between bovines and therefore the chance of *Brucella* transmission may explain the higher prevalence in dairy herds. Generally, male bovines show higher level of infection than females, probably reflecting differences in vaccination rates. No data is available on the prevalence of *Brucella* infection in swine, caprines, ovines and canines. One survey carried

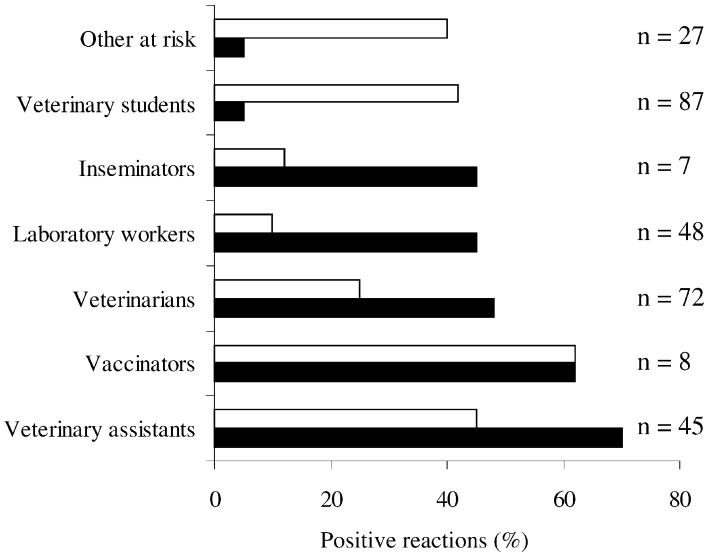

Fig. 1. Distribution anti-*Brucella* antibodies (ELISA) among individuals at risk of *Brucella* infections in Costa Rica. Relative IgG titers (white bars); relative total titters (black bars). Other at risk, corresponds to individuals who are in contact with aborted fetuses and non-pasteurized dairy products.

out in 1996 by the Veterinary School in the three major swine farms in Costa Rica did not reveal the presence of antibodies against *Brucella*.

All CA countries are obligated to report human brucellosis, but systematic records are scarce (http://www.oie.int). In an 8-year survey, 156 cases of human brucellosis (*B. abortus*) were reported to the Ministry of Health in Costa Rica (Ministerio de Salud, 1977–1984). It is likely that the number of cases was underestimated, since health services in CA have not considered necessary to take the appropriate measures toward the surveillance of human brucellosis. In a serological survey performed in Costa Rica (Campos et al., 1984), a prevalence of 45% was found in a high risk population of 384 individuals (Fig. 1). Vaccinators showed the more active infections (higher titers of IgG) and half of them declared clinical symptoms. Strikingly, the Ministry of Health did not keep records of these cases. The ingestion of non-pasteurized dairy products by the rural and to less extent by the urban population is a common practice in CA (Ministerio de Salud, 1984–1990). The high prevalence of antibodies in individuals at risk constitutes an indirect evidence of the frequent distribution of *Brucella* animal infections in CA.

6. Control programs

Most CA countries have initiated programs for the control of brucellosis, with the economical and technical help of international agencies (Gonzales et al., 1980;

http://ns1.oirsa.org.sv). Even though some of these actions have contributed to establish vaccination, surveillance and quarantine programs, in time they have suffered economical constraints with unfortunate consequences (http://www.oie.int). For instance, in 1940 Costa Rica had a population of about one million inhabitants and a severe brucellosis problem in dairy farms (Sáenz-Maroto, 1943; Williams-Tasara, 1951). After 60 years, brucellosis remains practically the same in this country, despite the fact that in two occasions National Control Programs, with duration from 5 to 10 years have been implemented (Gonzales et al., 1980). In 1978 the Ministry of Agriculture of Costa Rica initiated actions towards the control of bovine brucellosis. The aim was to reduce the prevalence from 8–12 to 2% during the first 8 years (Vicente et al., 1983). By 1988 the prevalence in some of the endemic areas (Cartago Province) was reduced to 4%, however, after the Program gradually declined (mainly due to financial constraints), the prevalence steadily increased to its previous level. It is important to stress that Costa Rica is the country with the highest rate of veterinarians, the most politically stable and the country possesses the most facilities for the control of infectious diseases in CA (http://www.fao.org; http://www.oie.int).

All the CA Programs for the control of brucellosis have been based on calf vaccination and elimination of the reactors. Although, serological survey of the national herds is required, this has been achieved only in El Salvador from 1995 to 1997 (close to 80%) and partially in the early 1980s in Costa Rica (close to 30%). Until 1998 *B. abortus* S19 was the official vaccine. Low-dose S19 vaccine was introduced in 1990, however the management and administration of this vaccine did not differ from the complete-dose vaccine. *B. abortus* RB51 introduced in 1998 is presently the only vaccine available in most CA countries. Independently of the vaccine type, a conjuctival vaccination has rarely been applied in CA. Adult vaccinations and revaccination are commonly unregulated practices among farmers, mainly in areas of high prevalence. It is still difficult to evaluate the efficiency of *B. abortus* RB51 in CA. Recent studies in areas of high prevalence revealed significantly higher rates of abortion and infection in RB51 than in S19 vaccinated herds in previous years (Moreno and Blasco, manuscript in preparation). Rev 1 vaccine has been used sporadically in ovine and caprine herds in Guatemala.

Even though it is an unpleasant fact, it must be admitted that the control of brucellosis in CA has been a failure. The most likely reasons for this failure are summarized as follows. First, it seems that calf vaccination is an unsuccessful procedure in countries where very limited experience and poor economical support does not allow extensive serological survey of the national herd with the concomitant removal of the reactors. The logic behind calf vaccination implies extensive surveys and constant identification and removal of the positive bovines. Second, the economy of the CA countries makes it extremely difficult to subsidize slaughtering of the reactors; this indirectly favors the hiding, clandestine sale and movement of infected cattle. Third, the high density of *Brucella* infections and the low vaccine protection rate favors the spreading of the bacteria among susceptible animals and facilitates occult infections among susceptible vaccinated cattle. Fourth, the acquisition of several vaccine types by private enterprises has favored the undisciplined vaccination, revaccinations and the poor management of the vaccines.

7. Concluding remarks

Elimination of brucellosis in CA cannot be achieved just by the application of fixed strategies used in other latitudes. The control and prevention of brucellosis is far more complex than vaccination, testing and slaughtering of the reactors. Each country and each region has its own characteristics that must be considered at the time of initiating a program towards the elimination of the disease. The first measures in CA must be directed to restrict the spreading of the bacteria and to reduce the abortion rates. These could be achieved by extensive and unrestricted adult vaccination by the conjuctival route with S19, concentrating efforts in dairy cattle. This exercise is known to practically eliminate the clinical disease and to diminish the degree of infection of healthy cattle (Nicoletti, 1980). Caution in the use of vaccines that have not been proved to control and eradicate brucellosis is mandatory, mainly in areas of high prevalence. Consequently, the use of well known S19, in combination with tests that discriminate between infected and vaccinated animals is convenient (Gall et al., 1998), mainly in a region where experimentation with new vaccines is not affordable. By following this strategy, revaccination and immunization of infected animals inevitably would occur, complicating the serological discrimination. In any case, the diagnosis in CA is already very limited and restricted to exportations and to trade activities, and therefore it does not represent an immediate problem. After few years, this strategy would reduce the prevalence and density of the bacteria in the bovine population to numbers where ‘‘clean’’ vaccination would be possible. Then, serological identification and elimination of the reactors could be initiated under more favorable conditions of herd infection. Although brucellosis is complex and difficult to control, countries about the same size as those in CA have eradicated the disease. The control of brucellosis is achieved by joint efforts between the producers and governmental authorities. Without cooperation between these parties, even a very good strategy will fail.

Acknowledgements

This work was supported by the MICIT/CONICIT of Costa Rica.

References

Arellano, C., Framk, J., Howart, J.A., Palacios, C., Seaton, V.A., Acha, P., Murnane, T.G., 1981. Informe de comisión de evaluación de los laboratorios de diagnóstico veterinario en las Americas. Instituto Interamericano de Cooperación para la Agricultura (Costa Rica). Series: Salud Animal, Publicación Científica No. 2, pp. 1–87.

Campos, E., Vicente, G., Ramirez, J.A., Moreno, E., 1984. Evaluación seroepidemiológica de la brucelosis humana en poblaciones de riesgo ocupacional. Acta Med. Cost. (Costa Rica) 47 (Suppl.), 8–9.

Gall, D., Colling, A., Mariño, O., Moreno, E., Nielsen, K., Pérez, B., Samartino, L., 1998. Enzyme immunoassays for the serological diagnosis of bovine brucellosis trial in Latin America. Clin. Diag. Lab. Immunol. 5, 654–661.

Gonzales, S., Vicente, G., Gutierrez, L., 1980. Vigilancia de las enfermedades transmisbles. Programa Nacional de Salud Animal (PRONASA), Ministerio de Agricultura y Ganadería/Banco Interamericano de Desarrollo, Costa Rica, pp. 1–27.

Ministerio de Salud. Departamento de Zoonosis, 1977–1984. Reportes anuales sobre brucelosis humana en Costa Rica. Enfermedades de comunicación obligatoria. San José, Costa Rica.

Ministerio de Salud. Departamento de Control de Alimentos, 1984–1990. Rreportes sobre decomiso de leche de productos lácteos no pasteurizados. San José, Costa Rica.

Nicoletti, P., 1980. The epidemiology of bovine brucellosis. Adv. Vet. Sci. Comp. Med. 24, 70–98.

Pérez-Roman, C.E., Nema-Viddaurre, J.M., Araya-Fonseca, E., 1984. Brucelosis en personal del matadero de Nicoya Guanacaste. Acta Med. Cost. (Costa Rica) 27, 41–44.

Rojas, N., Zamora, O., Cascante, J., Garita, D., Moreno, E., 2001. Comparison of the antibody response in adult cattle against different epitopes of *Brucella abortus* lipopolysaccharide. J. Vet. Med. 48, 623–629.

Sáenz-Maroto, A., 1943. Primeras investigaciones sobre aborto contagioso en Costa Rica. Thesis, Escuela de Agronomía, Universidad de Costa Rica, San José, Costa Rica, pp. 1–56.

Sequeira, A., Campos, E., Mendoza, L., San-Román, M.A., Moreno, E., 1984. Identificación de especies y biotipos de *Brucella* aisladas en Costa Rica. Turrialba 34, 525–526.

Vicente, G., Kirschbaun, A., Ureña, M., 1983. Consideraciones sobre la vacunación antibrucelosa en Costa Rica, 1978–1982. Cien. Vet. (Costa Rica) 123–126.

Williams-Tasara, O., 1951. La brucelosis bovina y humana. Estudio preliminar. Thesis, Universidad de Costa Rica, San José, Costa Rica, pp. 1–47.