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PREVALENCE AND CONTROL OF BABESIOSIS IN THE AMERICAS

SONIA MONTENEGRO-JAMES

Department of Tropical Medicine, Tulane University, SPHTM, 1501 Canal St., New Orleans, LA 70112, U.S.A.

This review presents up-to-date information on the distribution and control measures of babesiosis in Latin America. Bovine babesiosis caused by Babesia bovis *and* B. bigemia *will be emphasized. The disease is endemic in most countries and poses a serious economic burden on livestock production in the region (U.S. $1365 million/year, FAO, 1989).*

Of the estimated 250 million cattle in Central and South America, approximately 175 million (70%) are in tick-infested regions. Humid, tropical and subtropical areas favor development of the main vector, the one-host tick Boophilus microplus. *In many regions bovine babesiosis is enzootically stable as a consequence of a balanced host-parasite relationship. However, Latin America offers a wide range of epidemiologic conditions that are influenced by variations from tropical to cool climates and by susceptible purebred cattle that are regularly imported to upgrade local stocks.*

The control measures employed in most countries for babesiosis essentially rely on chemotherapy, use of acaricides for B. microplus, *and to a lesser degree, on immunization methods. In general, these measures are expensive, time consuming, and in many cases, provide limited success.*

Finally, the zoonotic potential of babesiosis will be addressed, with special emphasis on the situation in the United States. Even though bovine babesiosis has long been eradicated from the U.S.A., human babesiosis is endemic in the northeastern region of the country.

Key words: *Babesia bovis* – *Babesia bigemina* – epidemiology – control in America

Babesiosis is a tick-transmitted protozoan disease of wild and domestic animals and has a world-wide distribution. At least 18 species are pathogenic to domestic and laboratory animals and to man (De Vos et al., 1987). Babesiosis has the greatest economic significance in cattle and remains one of the most important diseases in tropical and subtropical regions where approximately 600 million head are at risk (McCosker, 1981).

Most of Central and South America lie in the region of warm climates found between latitudes 30° North and 30° South (N-S 30°) of the equator. The N-S 30° region contributes almost half of the world's livestock production, yet it accounts for only 30% of the world meat output (Lombardo, 1976). The continent of South America includes 12 countries with a total area of 17,707,081 km^2. Approximately 216 million of the estimated total of 600 million cattle in the N-S 30° region are found in South America alone (McDowell, 1972). Although Latin America has twice as many cattle as the United States, the region produces less than half as much beef. The productivity ratio is 1:4, meaning Latin America feeds 4 times as many cattle as the U.S. in order to produce 1 ton of beef (McDowell, 1972). This ratio must be reduced to effectively expand food supplies and improve farm income.

Ticks and tick-borne diseases have long been incriminated as major obstacles to efficient livestock production. In South America, vast areas of grazing land, although inadequate for cultivation and occupied by indigenous breeds, could yield greater quantities of animal protein were it not for the constraints imposed by tick-borne diseases on the importation of improved European breeds (Smith, 1977). At present, average rates of dairy and beef production in this region are only 10-25% of acceptable values found in the northern latitudes (McDowell, 1972). Pressed by the need for economic improvement, most Latin American countries have attempted to increase the efficiency of commercial cattle operations by importing more productive breeds from countries with temperate climates. However, imported cattle are highly susceptible to tick-borne diseases and fare poorly when introduced into endemic areas. Babesiosis is known to cause morbidity and mortality in susceptible cattle residing in tick-infested areas of Mexico, and Central and South America (Pino, 1981). Methods presently available for the control of these diseases rely almost entirely upon the use of chemotherapeutic drugs or acaricides for the control of ticks. Undoubtedly, to implement effective control measures, renewed efforts are needed, particularly in acquiring a comprehensive understanding of tick biology and disease relationships.

Although not a major health problem, human babesiosis certainly cannot be considered a medical rarity. Human *Babesia* infections have in fact been well studied, and provide an example of the effects of environmental and behavioral factors on the spread of an infection (Healy, 1989).

DISTRIBUTION AND ECONOMIC IMPORTANCE OF BABESIOSIS IN LATIN AMERICA

Bovine babesiosis and anaplasmosis (caused by a rickettsia, *Anaplasma marginale*) are widespread in most Latin American countries. Both diseases are regarded as a complex since they frequently occur together. The highest prevalence is found in humid, tropical and subtropical regions (Lawrence & De Vos, 1990). In general, anaplasmosis is more prevalent than babesiosis. *Babesia bigemina* appears to be the most prevalent *Babesia* species, although *B. bovis* seems to be more pathogenic (Lora, 1981). Of the estimated 250 million cattle in Central and South America, approximately 175 million (70%) are in tick-infested regions between latitudes 33° North and 35° South of the equator (Lopez, 1977). Climatic conditions in those areas favor development of the one-host tick *Boophilus microplus*, the most important vector of bovine babesiosis in the region. Field studies conducted in Uruguay have demonstrated an annual output of up to six generations of *B. microplus* in certain areas (Nari et al., 1979). The distribution of ticks is restricted in regions of high altitude and low temperatures, especially the Andes mountain range and southern South America. In many areas of Central and South America and the Caribbean, *B. bigemina* and *B. bovis* are enzootically stable. The high rate of transmission of these hemoparasites results in most cattle becoming infected at a young age (Young, 1988).

Argentina

The area at risk of babesiosis is restricted to areas where *B. microplus* is present (up to 30° S), representing 82 million hectares with a cattle population of 12 million head in Northeast and Northwest Argentina (Spath et al., 1990). *Boophilus microplus* is found throughout the year in northeastern Argentina, with a peak incidence occurring at the end of the dry season. Other ticks species found are *Amblyoma cajennense, A. neumanni* and *A. parvum* (Guglielmone et al., 1990a). In this region more than 80% of the cattle become seropositive to *Babesia* spp. at 9 months of age. Babesiosis outbreaks are most frequently due to *B. bovis*. The Nelore breed (*Bos indicus*) presents lower infection rates with *Babesia* spp. than do the Criollo and Hereford breeds. Seroprevalence rates of 66%, 96% and 92%, respectively, have been reported in these breeds (Habich et al., 1984). Also Nelore cattle are known to exhibit the lowest level of *B. microplus* infestation (Mangold et al., 1986).

Uruguay

Uruguay, with an area of 176,215 km^2, is located in the temperate zone (30-35°S), and is marginal for tick development (2.5-3.0 tick generations/year) (Nari et al., 1979). However, *B. microplus* develops favorably in the northern part of the country where approximately 6 million cattle are found. Nari et al. (1979) have also reported ticks to reside in ecological zones at the extreme south of Uruguay (34° South). The southern region is submarginal for tick survival as development is limited by the low winter temperatures. The prevalence of •hemoparasites on farms located at various latitudes throughout the region has been studied. At 31.2°S positive reactors for *B. bovis* have been found in 87% of the farms. At 32°S, 61.2% and 69.2% of farms were positive for *B. bovis* and *B. bigemina*, respectively. In more southern latitudes (e.g., 33.5°S), no farms were positive for either *Babesia* species (Nari et al., 1979).

The cattle population in the South is affected by conditions of enzootic instability and the animals are routinely premunized. The negative impact of hemoparasites on cattle performance has been shown by Nari et al. (1979). After 140 days, carriers of *Babesia* spp. demonstrated decreased weight gain (-26.1%) as compared with uninfected cattle. Livestock in Uruguay, consisting of over 9 million head, are composed almost exclusively of *Bos taurus* breeds. Cattle are regularly exported to neighboring Brazil and Paraguay.

Paraguay

A recent serological survey reported that *B. bigemina* and *B. bovis* are widespread in the eastern region of Paraguay, and in much of the South and Central Chaco with rates of 79% and 71%, respectively (Payne & Osorio, 1990). An enzootically stable situation exists with regard to these parasites over much of the country. The livestock industry of Paraguay is based on beef production with only 3% of the 6 million cattle being utilized in the dairy sector. Cattle breeds are mainly Criollo (*Bos taurus* of Spanish descent) and Hereford-Zebu crossbreeds. *Boophilus microplus* is the predominant cattle tick in Paraguay with a widespread, year-long presence in cattle-rearing regions.

Bolivia

A high prevalence of antibodies to *B. bovis* (97%) has been found in dairy cattle in the tropical, eastern region of the country (Santa Cruz) (Nichols et al., 1980). Imported *Bos taurus* suffer heavy losses when introduced into this endemic area.

Brazil

Brazil occupies an area of 8.5 million km^2 in eastern South America and has a cattle population of approximately 120 million head. The country consists of 3 large agricultural regions: (1) *Amazon Region* is composed of 7 states and is characterized by the Amazon rain forest with a warm, humid climate; (2) *Northeast Region* constitutes 9 states with a characteristically semi-arid climate; and (3) *Mid-South Region* encompasses 10 states and is characterized by both tropical and temperate climates. Bovine babesiosis and *B. microplus* are widespread in the Brazilian territory except for a small marginal zone in the southern state of Rio Grande do Sul located below latitude 32° S.

Most cases of cattle "tristeza" (anaplasmosis and babesiosis) occur in the southern region where most breeds are of European origin (*Bos taurus*). The prevalence of bovine babesiosis in Rio Grande do Sul decreases from North to South revealing 3 epidemiologically distinct zones: endemic zone (30.3° - 31.3°S) - *B. bigemina* = 94.2%, *B. bovis* = 93%; marginal zone (31.3°S - 33°S) - *B. bigemina* = 68.4%, *B. bovis* = 61%; clean zone (below 33°S), no babesiosis (Leite, 1988). In Minas Gerais babesiosis has an average prevalence of 82.5% and 79% for *B. bovis* and *B. bigemina*, respectively (Patarroyo et al., 1987). In Mato Grosso do Sul, babesiosis (82.2%) is more prevalent than anaplasmosis (40.3%) (Madruga et al., 1983).

Colombia

Located in the northwestern part of South America, Colombia has an area of 1.14 million km^2 of which 44 million hectares are suitable for grazing. By 1979, the cattle population was 27.1 million head, the majority raised for beef production. Cattle represent 87% of the country's livestock and contributes 38.7% of all agricultural output (Vizcaino, 1981). The Colombian Andes form 3 parallel mountain ranges that divide the country longitudinally into 3 major climatic zones: a hot lowland zone with an altitude below 800m; an intermediate zone between 800 to 2100m; and a high zone about 2100m with an average annual temperature of 13°C. The distribution of babesiosis is influenced by climate. No disease or ticks have been reported at altitudes above 2200m (Corrier et al., 1978). Tropical and subtropical climates cover nearly 90% of the territory, providing favorable conditions for hemoparasites and their tick vectors. Twenty-three million head (85%), consisting of Criollo, Zebu, and crossbred beef cattle, reside in endemic areas. Dairy cattle (approximately 4 million animals) of *Bos taurus* breeds (Holstein, Brown Swiss) are found in tick-free, high altitude areas and in the subtropical intermediate zone. Serious losses have been reported in dairy farms where susceptible calves are exposed to ticks (Vizcaino, 1981).

The highest serological prevalence has been reported on the Caribbean Coast followed by the Eastern Plains (Llanos Orientales), and the Andean region (Vizcaino, 1981). The most prevalent *Babesia* parasite is *B. bigemina* followed by *B. bovis*. Except for the Caribbean coast where a situation of enzootic stability exists throughout the zone, epidemics are known to occur in other regions (Gonzalez et al., 1978). Further information regarding the epidemiologic characteristics of hemoparasites in Colombia is presented in Table I.

It has long been considered that enzootic stability (abundant ticks and a high rate of parasite transmission result in most cattle becoming infected at an early age) is desirable and economically acceptable because it precludes diseases outbreaks and mortality (Dalgliesh et al, 1990). However, studies by Vizcaino (1981) and Mullenax (1986) with Zebu-cross cattle and dairy cattle in stable areas of the Eastern Plains and Cauca Valley have challenged that notion. Chronic carriers of blood parasites exhibit decreased productivity as manifested by: delayed conception, retarded growth, weight loss or reduced weight gains, reduced milk production, depreciated hides and lower market value.

Although it is difficult to separate production losses caused by the effects of babesiosis from those caused by climate, nutritional stress, ecto- and gastrointestinal parasites and other diseases, the negative impact of hemoparasitic diseases exists even under conditions of enzootic stability. An estimate of the economic losses caused by hemoparasitic diseases in the Americas is presented in Table II.

Venezuela

Located in northern South America, Venezuela has an area of 912,050 km². A large portion of the territory is part of the Orinoco River basin. The country can be divided into 3 regions: (1) coast and mountains, (2) Orinoco plains, and (3) Guyana region. Only the first two regions are relevant for livestock production. The cattle population consists of 10.53 million head, 38.4% are for dairy (4.05 million) and 61.6% for beef (6.48 million) production. In the first region, the Colombian Oriental mountain range merges into two separate ranges named Perija and Merida. Those surround Lake Maracaibo and the Gulf of Maracaibo. To the east and parallel to the litoral lies the Caribbean mountain range. In this region the climate varies from tropical to temperate to cool according to the altitude. Most dairy farms are located in this region with 85% of milk produced in the states of Zulia, Lara, Falcon, Tachira, Merida and Trujillo. The most common breeds are *Bos taurus* (Holstein, Brown Swiss) and Criollo crosses (Carora breed) or Brahman (Siboney breed). An important contingent of purebred Holstein cattle are imported annually from the U.S.A., New Zealand and Canada (Alvarez del Real., 1987).

Beef farms are concentrated in the Venezuelan plains located south and southeast of the Merida and Caribbean mountain ranges west of the Orinoco River. This area consists of savannah grasslands where cattle operations are extensive in nature with open range-type management. Predominant cattle breeds are Zebu, Criollo, and Zebu-Criollo crosses. The principal beef-producing states are Apure, Barinas, Portuguesa, Cojedes, Guarico, Anzoategui and Monagas (Alvarez del Real, 1987). Seroepidemiological surveys conducted in dairy farms of the midwestern region of Venezuela have found more cattle seropositive to *B. bigemina* (78.2%) than to *B. bovis* (38.8%) (James et al., 1985). Venezuela offers a wide range of epidemiologic conditions because highly susceptible purebred cattle are imported regularly. The diversity of management practices, geographic characteristics, farm size, etc. affects a milieu that provides varying degrees of enzootic stability for these infections. Sero-prevalence studies carried out in major cattle regions of Venezuela indicated that the average prevalence for *B. bovis* was 33.1%, ranging from 6.3% to 79.4%, with the mean *B. bigemina* prevalence = 47.1% (range 2.2% to 89.5%) (Montenegro-James et al., 1989). Seventeen farms that were involved in the seroepidemiological studies demonstrated relatively low seroprevalence rates of bovine babesiosis (range 2.2% to 14.0%) for farms with systematic tick dipping and various degrees of cattle confinement, compared to 96% prevalence when sporadic dipping and grazing were practiced (Montenegro-James et al., 1989). In Zulia State and the various Andean and Centro Occidental states where dairy farms predominate, *B. bigemina* was found more often than *B. bovis*. The Centro Occidental region had the highest prevalence (80%) and the Andean region the lowest (40%). In beef-producing regions (Plains), the prevalence was similar for

TABLE I

Epidemiologic characteristics of hemoparasites in cattle - Important regions of Colombia (1979)

Region	Herd (mill) Breed	Hectares (mill)	Seroprev. *B. big.*	Seroprev. *B. bov.*	Patency *B. big.*	Patency *B. bov.*	Mortality %	Epid. Status
Caribbean	10.9	4.7						
North Coast	zebu	beef	57	–				
	criollo	beef						
Barranquilla	crossbred	beef	50	38.1	7.6	7.6	2.2-7.7	stable
Valledupar			67.1	63.1	15.4	7.6		
Llanos Orient.	3.4		62-64	67.3				
Piedemonte	Z/Cr/Cb	Beef	40.1	41.6	9	9		stable
Sabana								unstable
Andean	3.47	dairy	46.6	26.0			3.7-18	unstable
	B. taurus							
V. del Cauca	6.81	double	62.5	65.4				
	Z/Cr/Cb	beef	87.4	44.4				
La Dorada				51.7				
Manizales			27.8	26.9	9	9		
Bucaramanga			50.8	53.2	10	10		

Adapted from Vizcaino, O., 1981. ICA-IICA Bull. N° 251.

TABLE II

Estimate of economic losses associated with anaplasmosis and babesiosis in the Americas

Country/ Region	Cattle No. (millions)	Pathogen(s) enzootic *status*	Total cost ($ million/yr)	Average $ cost/head/yr	Reference
Mexico	35.0	enzootic/ nonenzootic	287	8.2	Masiga, 1981
Colombia	27.1	enzootic- nonenzootic			
(Llanos)	22.0	stable enzootic	133	3.2	Mullenax, 1986
Brazil	122.6	enzootic- nonenzootic			
R. do Sul	9.89	enzootic- nonenzootic	99	9.9	Min. of Agric., 1983
Argentina (north)	22.0·	enzootic- nonenzootic	120		Guglielmone et al., 1990
Venezuela	10.0	enzootic- nonenzootic	23.3[a]		FONAIAP-MAC, 1985
C. America	58.0	enzootic- nonenzootic	850	3.12	PAHO, 1976
S. America	215.6	enzootic- nonenzootic	1365-1638	5.6	FAO, 1989

a: mortality only.

both parasites (60%) (Montenegro-James et al., 1989).

Guyana

Babesia infections in cattle are widely distributed with a high prevalence found in all ecologically-defined regions of the country, i.e., coast, forest and savannah. The seroprevalence for *B. bigemina* has been reported at 80% (range 73.1%-100%), whereas the prevalence for *B. bovis* was 61.4% (range 45.2% to 88.2%) (Applewhaite et al., 1981).

Mexico, Central America and the Caribbean

Mexico has had a campaign to eradicate *B. microplus* and *B. annulatus* ticks since 1976. Most efforts have been concentrated in the northeastern region of the country where a quarantine belt exists along the Mexico-Texas (USA) border. Seroepidemiological studies in the States of Nuevo Leon, Tamaulipas and Coahuila demonstrated average herd prevalence rates of 50% and 56% for *B. bovis* and *B. bigemina*, respectively (Teclaw et al., 1985). Another seroprevalence study conducted in Guerrero State reported a prevalence of 77% for *Babesia* spp. (Fragoso & Milian, 1984), whereas in Veracruz a lower prevalence of 24.5% has been demonstrated (Lopez et al., 1983).

In El Salvador, a small country located on the Pacific coast of the Central American isthmus, babesiosis and *B. microplus* are widespread throughout the country. Prevalence rates of 70.5% for *B. bigemina* and 73.5% for *B. bovis* have been reported (Payne & Scott, 1982). These findings are indicative of enzootic stability. However, from the number of recorded clinical outbreaks, these parasites still present a serious problem for the national dairy industry (Payne & Scott, 1982).

In Cuba, the 3 most important blood parasites of cattle are *A. marginale, B. bovis* and *B. bigemina*. Economic losses attributable to ticks and associated diseases have been estimated at US$ 23/head /year. Since 1987 a surveillance system for tick-borne diseases has been established for the 14 provinces of the country (Rodriguez et al., 1989). On the island of St. Lucia of the Windward Islands group in the Caribbean, *Babesia* spp. and *B. microplus* are widely distributed with prevalences of 65% and 64% for *B. bigemina* and *B. bovis*, respectively (Knowles & Montrose, 1982). Clinical cases are rare in native cattle; however, babesiosis outbreaks in imported Holstein calves indicate the danger of introducing susceptible cattle in *Babesia*-endemic areas.

CONTROL MEASURES FOR BABESIOSIS IN LATIN AMERICA

Control measures employed in Latin American countries for babesiosis essentially rely on chemotherapy, use of acaricides to control *B. microplus*, and to a lesser degree, on immunization methods. In general these measures are expensive, time-consuming, and in many cases, provide limited success.

Chemotherapy – Diamidine derivatives (Berenil®, Ganaseg® Pirobenz®) are frequently used. Imidocarb (Imizol®) is also recommended for chemoprophylaxis. Treatment before or after use of premunizing vaccines is common in order to avoid the occasional severe response to vaccination (Anon., 1988).

Tick Control – The most commonly used acaricides are pyrethroids, formamidine and organophosphorous compounds. Initially, ambitious aims toward tick-eradication induced several countries to engage in expensive and unsuccessful national tick control campaigns. Argentina, Colombia, Costa Rica, Cuba, Mexico, and Uruguay developed such programs. Problems with cost, acaricide resistance, infrastructure and maintenance were important deterrents. Argentina, Brazil, Colombia, Cuba, Mexico, Venezuela, and Uruguay have reported widespread organophosphate-resistant *B. microplus* strains (Anon., 1987). In most countries, current strategies have attempted to eradicate ticks in submarginal areas and to control the vector in endemic areas. The latter approach has been one of discretional suppression in which the livestock owner makes a decision to reduce tick populations.

Immunization – Based on the success achieved in Australia with the use of attenuated *B. bovis* and *B. bigemina* as vaccines against babesiosis, adaptation of these methods was attempted in the 1970s in Bolivia, Venezuela, Colombia and Uruguay. Argentina and Uruguay were true pioneers in the use of premunization techniques. The initial work of Prof. Jose Lignieres in Buenos Aires at the beginning of the century was followed by that of Prof. Miguel C. Rubino in Uruguay (Muskus et al., 1965). Possibly the lack of adequate technology, infrastructure and the availability of material have accounted for the limited effectiveness of those methods (Callow, 1974). Premunization utilizing local isolates has produced severe reactions that necessitate chemotherapy and veterinary surveillance in order to control disease (Todorovic & Tellez, 1975). In Brazil, premunization is frequently carried out by cattlemen without veterinary supervision. Limited amounts of attenuated *B. bovis* and *B. bigemina* vaccines are produced in a few veterinary research institutions (Kessler et al., 1987). In Colombia, irradiation-attenuated *B. bigemina* and *B. bovis* vaccines have proved effective in limited trials (Gil et al., 1987).

In Venezuela premunization was officially applied in all imported cattle by the Institute of Climatization and Premunization until the 1950s (Muskus et al., 1965). Recently, an inactivated culture-derived *B. bovis-B. bigemina* vaccine has been produced at the Veterinary Research Institute in Maracay and utilized in approximately 15,000 cattle with satisfactory results (Montenegro-James 1989; Toro et al., in press). A similar exoantigen-containing *B. bovis* immunogen has experimentally been applied in Mexico and Brazil.

Uruguay has utilized an attenuated *B. bovis* and *B. bigemina* vaccine derived from local isolates since 1941. Premunition procedures are adequately supervised. Cattle exported to Paraguay and Brazil are regularly vaccinated. Payne et al. (1990) have reported in Paraguay that although the *Babesia* vaccine generally performs satisfactorily, a number of vaccinated cattle may require treatment.

In Argentina premunization continues to be the most common method of immunization (Guglielmone, 1980). Limited use of live attenuated *Babesia* vaccines has proved satisfactory (Guglielmone et al., 1990b). A recent cost-benefit analysis indicated that there is considerable demand in Argentina for an effective vaccine(s) against hemoparasites (Spath et al., 1990).

Acceptable control measures for babesiosis in Latin America should be based on a comprehensive integration of immunization, chemotherapy and tick control according to the specific epidemiologic situation. An emphasis on selective components of the control strategy will depend on an understanding of epidemiologic trends and economic feasibility (Irvin, 1987).

Human babesiosis – A renewed interest in human babesiosis has been generated due to the growing number of reported cases, and because of its association with Lyme disease, a tick-borne disease of man and animals caused by the spirochete *Borrelia bergdorferi* (Benach et al., 1985). Babesiosis in humans is a malaria-like illness that ranges from asymptomatic infection to a severe, even fatal, disease associated with hemolytic anemia and severe systemic complications (Healy & Ristic, 1988).

Human *Babesia* infections are transmitted by ticks of the genera *Ixodes, Dermacentor* and *Boophilus* (Healy, 1979) and occasionally by transfusion and transplacental/perinatal passage (Esernle-Jenssen et al., 1987). Since automated blood analyzers do not differentiate between infected and uninfected erythrocytes, diagnoses must be made by microscopic examination of Giemsa-stained blood smears. A differential diagnosis from *P. falciparum* is required because *Babesia* ring forms closely resemble those of the malaria parasite (Hoare, 1980). Also, Pappenheimer bodies (iron-containing mitochondria) may appear morphologically similar to *Babesia* parasites, thereby falsely elevating the parasite count (Carr et al., 1991). Detection of low-level parasitemias undetected by blood film analysis can be accomplished by inoculation of patient blood into gerbils for the bovine parasite *B. divergens* and into hamsters for *B. microti* (Healy & Ristic, 1988). The sero-diagnosis of *B. microti* by the indirect fluorescent antibody test is frequently used for confirmation of the microscopic diagnosis and for epidemiologic studies (Chisholm et al., 1986).

In Europe, the bovine/equine *Babesia* spp. have caused the most severe disease; 8 of the 10 reported European cases were in splenectomized patients and 6 of them died. The presence of a spleen plays an important role in resistance to *Babesia* infections, whereas splenectomy exacerbates the disease. In the United States, 15 cases of babesiosis have been reported in splenectomized individuals (80% by *B. microti*) with all but one subsequently recovering (Rosner et al., 1984). Fatality cases in the U.S. have been associated with elderly or immunocompromised patients (Healy & Ristic, 1988). Treatment of human *Babesia* infections has included supportive therapy and a variety of antiparasitic drugs. Babesiacidal drugs such as diminacene aceturate (Ganaseg®) are effective only at highly toxic doses. Antimalarial drugs, e.g., chloroquine, have poor antibabesial activity and only provide a relief of symptoms. The combination of parenteral clindamycin phosphate (40 mg/kg) and oral quinine sulfate (25 mg/kg) for 10 days has been reported to be an effective treatment regimen (Esernle-Jenssen et al., 1987).

Human babesiosis in Europe differs both clinically and epidemiologically from that found in the United States, possibly reflecting differences in the tick-host relationship. In the United States, most cases are caused by *B. microti*. Fatal infections are rare and the disease is generally mild, self-limiting or asymptomatic (Healy & Ristic, 1988). Nearly 250 human *B. microti* infections have occurred on the coastal islands of the northeastern U.S. This endemic situation has prompted the States of Massachusetts and New York to consider human babesiosis as a reportable disease. Most of the known cases have resulted from exposure to the 3-host tick *I. dammini* (northern deer tick), the main vector of Lyme disease (Piesman et al., 1986). The tick infests a variety of mammals and birds with the white-tailed deer commonly the most heavily infested. As larvae, the vector tick feeds on rodents, especially the white-footed mouse or deer mice (*Peromyscus leucopus*). Deer mice demonstrate the highest rate (79%) of natural *B. microti* infections (Healy et al., 1976). Nymphs and adults also feed on deer. The former are known to attach to man during late summer to early fall, the season at which human infections usually occur (Healy, 1989). Deer are an important component of the epidemiology of human *B. microti* infections. The spread of *I. dammini* has paralleled the proliferation of white-tailed deer over the past few decades (Spielman et al., 1985). The introduction of deer (whether by humans or by natural migration) and deer ticks into favorable rodent-inhabited biotopes used for human recreational activities appears to have been responsible for the emergence of human babesiosis in the United States (Hoogstraal, 1981).

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REFERENCES

ALVAREZ DEL REAL, M.E., 1987. Ganaderia. p. 90-94. In M.E. Alvarez del Real, *Atlas de Venezuela* 2ª ed. Bloque de Armas, Venezuela.

ANON., 1987. Consulta de Expertos sobre Erradicacion de la Garrapata con Referencia Especial a las Americas y el Caribe. Historia de la Erradicacion de la Garrapata (Discusion - Recomendaciones). FAO, Mexico, 22-26 Junio.

ANON., 1988. Accion y toxicidad de los formacos utilizados contra la *Babesia bovis* y *Babesia bigemina*. *Veterinaria* (Montevideo, Uruguay) *24:* 15-24.

APPLEWHAITE, L.M.; CRAIG, T.M. & WAGNER, G.G., 1981. Serological prevalence of bovine babesiosis in Guyana. *Trop Anim. Hlth, Prod., 13:* 13-18.

BENACH, J.L.; COLEMAN J.L.; HABICHT, G.S.; McDONALD, A.; GRUNWALDT, E. & GIRON, J.A., 1985. Serological evidence for simultaneous occurrences of Lyme disease and babesiosis. *J. Infect. Dis., 152:* 473-477.

CALLOW, L.L., 1974. Epizootiology, diagnosis and control of babesiosis and anaplasmosis. Relevance of Australian findings in developing countries. *Bull. Off. Int. Epiz., 81:* 825-835.

CARR, M.J.; EMERY, S.; STONE, B. & TULIN, L., 1991. Babesiosis diagnostic pitfalls. *Am. J. Clin. Pathol., 95:* 774-777.

CHISHOLM, E.S.; SULZER, A.J. & RUEBUSH, T.K., 1986. Indirect immunofluorescence test of human *Babesia microti* infection-Antigenic specifity. *Am. J. Trop. Med. Hyg., 35:* 921-925.

CORRIER, D.E.; CORTES, J.M.; THOMPSON, K.C.; RIANO, H. BECERRA, E. & RODRIGUEZ, R., 1978. A field survey of bovine anaplasmosis, babesiosis and tick vector prevalence in the eastern plains of Colombia. *Trop Anim. Hlth Prod., 10:* 91-92.

CORRIER, D.E.; GONZALEZ, E.F. & BETANCOURT, A., 1976. Current information on the epidemiology of bovine anaplasmosis and babesiosis in Colombia, p. 114-120. In J.K.H. Wilde, *Tick-borne Diseases and Their Vectors*, University of Edinburgh Scotland.

DALGLIESH, R.J.; JORGENSEN, W.K. & DE VOS, A.J., 1990. Australian frozen vaccines for the control of babesiosis and anaplasmosis in cattle. A review. *Trop Anim. Hlth Prod., 22:* 44-52.

DE VOS, A.J.; DALGLIESH, R.J. & CALLOW, L.L., 1987. Babesia, p. 183-222. In E.J.L Soulsby, *Immune Responses in Parasitic infections: Immunology, Immunopathology and Immunoprophylaxis. Vol. III: Protozoa.* CRC Press, Boca Raton, Florida.

ESERNLE-JENSSEN, D.; SCIMECA, P.G.; BENACH, J.L. & TENNENBAUM, M.J., 1987. Transplacental/perinatal babesiosis. *J. Pediat., 110:* 570-572.

FRAGOSO, S. & MILIAN, S.F., 1984. Prevalencia de anticuerpos contra *Anaplasma marginale* y *Babesia* spp. en la zona centro del estado de Guerrero. *Tecnica Pecuaria en Mexico,* (Mexico) *47:* 133-136.

GIL, L.A.; HIGUERA, B. & URREGO, J., 1987. Experimental vaccine against *Babesia bovis* and *B. bigemina* produced by attenuation of the parasite through irradiation. *Rev. Med. Vet. & Zootec., 39:* 49-57.

GONZELEZ, E.F.; CORRIER, D.E.; TODOROVIC, R.A. & LOPEZ, G., 1978. Epidemiologia de la anaplasmosis y babesiosis bovina en el valle geografico del Rio Cauca. *Revista ICA* (Colombia), *13:* 349-356.

GUGLIELMONE, A., 1980. La prevencion de babesiosis y anaplasmosis en Argentina y Australia. *Rev. Med. Vet.* (Buenos Aires), *61:* 275-277.

GUGLIELMONE, A.A.; MANGOLD, A.J.; AGUIRRE, D.H. & GAIDO, A.B., 1990a. Ecological aspects of four species of ticks found on cattle in Salta, Northwest Argentina. *Vet. Parasitol., 35:* 93-101.

GUGLIELMONE, A.A.; MANGOLD, A.J., AGUIRRE, D.H. & CAIDO, A.B., 1990b. Vacunas congeladas contra la babesiosis y la anaplasmosis de los bovinos: Viabilidad luego del descongelado. Proc. 12th Pan. Am. Cong. Vet. Sci. p. 28.

HABICH, G.E.; AGUIRRE, D. & GONZALEZ DE RIOS, L., 1984. Anticuerpos contra *Babesia bovis* en bovinos Nelore, Criollo y Hereford en la provincia de Tucuman, Rep. Argentina. *Revista Argentina de Produccion Animal* (Argentina), *4* (Sppl. 1): 874-878.

HEALY, G.R., 1979. Babesia infections in man. Hospital Practice. June: 107-116.

HEALY, G.R., 1989. The impact of cultural and environmental changes on the epidemiology and control of human babesiosis. *Trans R. Soc. Trop. Hyg., 83* (Suppl.): 35-38.

HEALY, G. & RISTIC, M. 1988. Human babesiosis, p. 209-226. In M. Ristic, *Babesiosis of Domestic Animals and Man.* CRC Press, Inc. Boca Raton, Florida.

HEALY, G.R.; SPIELMAN, A. & GLEASON, N., 1976. Human babesiosis: reservoir of infection on Nantucket Island. *Science, 192:* 479-481.

HOARE, C.A., 1980. Comparative aspects of human babesiosis. *Trans. R. Soc. Trop. Med. Hyg., 74:* 143-148.

HOOGSTRAAL, H., 1981. Changing patterns of tick-borne diseases in modern society. *Ann. Rev. Entomol., 26:* 75-80.

JAMES, M.A.; CORONADO, A.; LOPEZ, W.; MELENDEZ, R. & RISTIC, M., 1985. Seroepidemiology of bovine anaplasmosis and babesiosis in Venezuela. *Trop. Anim. Hlth Prod., 17:* 9-18.

KESSLER, R.H.; SACCO, A.M.S.; DE JESUS, E.F. & MADRUGA, C.R., 1987. Development of live attenuated strains of *Babesia bovis:* preliminary test. *Pesq. Agropec. Bras., 22:* 1225-1230.

KNOWLES, R.T. & MONTROSE, M., 1982. Clinical and serological evidence of bovine babesiosis and anaplasmosis in St. Lucia. *Vet. Parasitol., 10:* 307-311.

LAWRENCE, J.A. & DE VOS, A.J., 1990. Methods currently used for the control of anaplasmosis and babesiosis: their validity and proposals for future control strategies. *Parasitologia, 32:* 63-71.

LEITE, A., 1988. Prevalência sorológica de *Babesia bigemina* e *Babesia bovis* em 33 propriedades na zona sul do Rio Grande do Sul. Thesis UFPEL, Pelotas, RS, Brazil.

LOMBARDO, R.A., 1976. Socioeconomic importance of the tick problem in the Americas. *PAHO Scientific Publ. No, 326:* 79-89.

LORA, C.A., 1981. Methods of immunization against bovine babesiosis used in Latin America, p. 567-572. In M. Ristic & J.P. Kreier (eds) *Babesiosis* Academic Press, New York.

LOPEZ, G., 1977. Necesidades futuras en investigacion sobre garrapatas en Colombia. *Revista Vet. Venezolana, 42:* 95-105.

LOPEZ, F.; FAJARDO, J. & CANTO, G., 1983. Prevalencia de anticuerpos contra anaplasmosis y babesiosis e incidencia de infeccion diaria de babesiosis en bovinos del municipio de Playa Vicente, Veracruz. *Tecnica Pecuaria en Mexico* (Mexico) *44:* 82-85.

McCOSKER, P.J., 1981. The global importance of babesiosis, p. 1-20. In M. Ristic & J.P. Kreier (eds) *Babesiosis.* Academic Press. New York.

McDOWELL, P.E., 1972. The role of livestock in the warm climates, p. 3-20. In P.E. McDowell, *Improvement of livestock production in warm climates.* W.H. Freeman, San Francisco.

MADRUGA, C.R.; AYCARDI, E. & PUTT, N., 1983. Epidemiologia da anaplasmose e babesiose em bovinos da região do cerrado do estado do Mato Grosso do Sul. I. Prevalência. *Arq. Bras. Med. Vet. Zoot., 35:* 631-640.

MANGOLD, A.J.; AGUIRRE, D.H.; BERMUDEZ, A.C. & GUGLIELMONE, A.A., 1986. Infestaciones naturales de bovinos Hereford, Criollo y Nelore con *Boophilus microplus. Veterinaria Argentina, 3:* 238-246.

MONTENEGRO-JAMES, S., 1989. Immuno-prophylactic control of bovine babesiosis: role of exoantigens of *Babesia. Trans. R. Soc. Trop. Med. Hyg., 83* (Suppl.): 85-94.

MONTENEGRO-JAMES, S.; KAKOMA, I. & RISTIC, M., 1989. Culture-derived *Babesia* exoantigens as immunogens, p. 61-98. In I.G. Wright, *Veterinary Protozoan and Hemoparasite Vaccines.* CRC Press, Inc., Boca Raton, FL.

MULLENAX, C.H., 1986. Estimated production and dollar losses due to stable enzootic anaplasmosis and babesiosis in the Colombian Llanos (1981-1984). *Proc. Ann. Meet. Anapl. Res. Workers,* Baton Rouge, LA, 21-23 Sept., p. 2-16.

MUSKUS, C.; GARCIA, F.M. & DORTA, R.A., 1965. El control de la piroplasmosis en Venezuela. Aclimatacion, alimentacion y premunicion de los animales importados. *Rev. Vet. Venezolana, 18:* 277-302.

NARI, A.; SOLARI, M.A. & CARDOZO, H., 1979. Estudio preliminar sobre la ecologia de *B. microplus* en Uruguay. *Veterinaria* (Montevideo, Uruguay), *15:* 25-31.

NICHOLLS, M.J.; IBATA, G. & VALLEJOS, F., 1980. Prevalence of antibodies to *Babesia bovis* and *A. marginale* in dairy cattle in Bolivia. *Trop. Anim. Hlth Prod., 12:* 48-49.

PATARROYO, J.H.; RIBEIRO, M.F.; SANTOS, J.L. & FARIA, J.E., 1987. Epidemiologia das babesioses bovinas no estado de WMinas Gerais. I. Prevalencia de anticorpos fluorescentes na zona da Mata. *Arq. Bras. Med. Vet. Zoot., 39:* 423-429.

PAYNE, R.C. & OSORIO, O., 1990. Tick-borne diseases of cattle in Paraguay. I. Seroepidemiological studies on anaplasmosis and babesiosis. *Trop. Anim. Hlth Prod., 22:* 53-60.

PAYNE, R.C.; OSORIO, O. & YBANEZ, A., 1990. Tick-borne diseases of cattle in Paraguay. II. Immunization against anaplasmosis and babesiosis. *Trop. Anim. Hlth Prod., 22:* 101-108.

PAYNE, R.C. & SCOTT, J.M., 1982. Anaplasmosis and babesiosis in El Salvador. *Trop. Anim. Hlth. Prod. 14:* 75-80.

PIESMAN, J.; MATHER, T.N.; TELFORD, S.R. & SPIELMAN, A., 1986. A concurrent *Borrelia burgdorferi* and *Babesia microti* infection in nymphal *Ixodes dammini. J. Clin. Microbiol. 24:* 446-447.

PINO, J.A., 1981. The neglected diseases of livestock, p. 545-554. In M. Ristic & J.P. Kreier (eds) *Babesiosis.* Academic Press. New York.

RODRIGUEZ, O.N.; ESPAINE, L.; RIVAS, A. & RODRIGUEZ, P., 1989. Epidemiology of cattle diseases caused by hemoparasites in Cuba. *Revista Cubana de Ciencias Veterinarias, 20:* 37-56.

ROSNER, F.; ZARRABI, M.H.; BENACH, J.L. & HABIOCHT, G.S., 1984. Babesiosis in splenectomized adults. Review of 22 reported cases. *Am. J. Med., 76:* 696-701.

SMITH, R.D., 1977. Current world research on ticks and tick-borne diseases of food-producing animals. *Interciencia, 2:* 335-344.

SPATH, E.J.; MANGOLD, A.J. & GUGLIELMONE, A.A., 1990. Estimation of the potential demand for a bovine babesiosis and anaplasmosis vaccine in Argentina. *Vet. Parasitol., 36:* 131-140.

SPIELMAN, A.; WILSON, M.L.; LEVINE, J.F. & PIESMAN, J., 1985. Ecology of *Ixodes dammini*-borne human babesiosis and Lyme disease. *Ann. Rev. Entomol., 30:* 439-460.

TECLAW, R.F.; ROMO, S.; GARCIA, Z.; CASTANEDA, M. & WAGNER, G.G., 1985. A seroepidemiologic study on bovine babesiosis in the Mexican states of Nuevo Leon, Tamaulipas and Coahuila. *Prev. Vet. Med., 3:* 403-415.

TODOVORIC, R.A. & TELLEZ, C.H., 1975. The premunization of adult cattle against babesiosis and anaplasmosis in Colombia, South Ameria. *Trop. Anim. Hlth., Prod., 7:* 125-131.

TORO, M.; MONTENEGRO-JAMES, S.; LEON, E.; GUILLEN, A.T. & LOPEZ, R. Field evaluation of an inactived bivalent (*Babesia bovis - Babesia bigemina*) vaccine against babesiosis. *Veterinaria Tropical* (in press).

VIZCAINO, O., 1981. Impacto economico de los hemoparasitos y sus vectores en ganado de leche. *Revista ICA* (Colombia), *N251:* 37-51.

YOUNG, A.S., 1988. Epidemiology of babesiosis, p. 81-98. In M. Ristic *Babesiosis of Domestic Animals and Man.* CRC Press, Boca Raton, Florida.