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EPIDEMIOLOGY OF TICK-BORNE DISEASES OF CATTLE IN ZIMBABWE. I. BABESIOSIS

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SUMMARY

A survey on the incidence of antibodies to Babesia bigemina *and* Babesia bovis *in one to three year old calves at 274 localities in Zimbabwe revealed that* B. bigemina *occurred throughout the country together with its main vector,* Boophilus decoloratus. *The distribution of* B. bovis *followed closely that of its vector* Boophilus microplus *which is limited to the eastern part of the country. Enzootic stability for* B. bigemina *was recorded in most of the communal tribal areas where regular dipping of cattle had been interrupted for several years but was less common on commercial farms where regular dipping is practised. Enzootic stability for* B. bovis *was restricted to a few localities in communal areas and the parasite was rare on commercial farms.*

INTRODUCTION

Short-interval dipping of cattle for tick control was introduced in Zimbabwe (then Rhodesia) in 1914 to control East Coast fever (*Theileria parva parva*) which had been introduced into the country in 1901 with cattle imported from Tanzania (Lawrence and Norval, 1979). East Coast fever was rapidly brought under control by dipping and was finally eradicated in 1954. Other tick-borne diseases including babesiosis *(Babesia bigemina)*, anaplasmosis *(Anaplasma marginale)*, heartwater *(Cowdria ruminantium)* and theileriosis *(Theileria parva bovis)* were also effectively controlled and even appeared to have been eradicated from some areas. *Babesia bovis* was never a serious problem and was restricted to a few commercial farms on the eastern border. By the 1950s tick-borne disease had ceased to be a significant cause of cattle mortality (Lawrence and Norval, 1979). Short-interval dipping continued throughout the country until the escalation of the pre-independence war in the mid-1970s disrupted dipping in most of the communal tribal areas. Epidemics of babesiosis, anaplasmosis, heartwater, and theileriosis followed and it was estimated that about one million cattle died (Norval, 1979; Lawrence, Foggin and Norval, 1980).

The epidemics of tick-borne disease are thought to have occurred because of the development of an unstable state in which continuous dipping over many decades had led to an interruption in the transmission of tick-borne pathogens and the creation of a highly susceptible cattle population (Norval, 1979; Lawrence *et al*, 1980). In the light of this experience there is an obvious need to re-assess the role of dipping in the control of tick-borne diseases. Norval (1981) suggested that short-interval dipping need not be re-introduced in areas where enzootic stability (Callow, 1977) is known to exist. To obtain detailed information on the occurrence of enzootic stability a nationwide epidemiological survey has been undertaken. This is the first in a series of papers reporting findings of the survey and deals with babesiosis.

B. bigemina has been known to be present in Zimbabwe since the arrival of the first white settlers in the 1890s when the disease caused considerable mortality in imported cattle (Lawrence and Norval, 1979). The introduction of dipping did much

to control the disease and Matson (1965, 1966) noted that most cases of *B. bigemina* infection occurred after cattle had been moved from one locality to another. It was generally believed that *B. bigemina* did not occur in the dry southern and western parts of Zimbabwe and the disease was not recorded as a cause of cattle deaths in these areas after the disruption of dipping during the pre-independence war (Norval, 1979). *B. bovis* was thought to have a very restricted distribution along the eastern border (Matson, 1965; Lawrence and Norval, 1979) until recently when it was confirmed in communal areas and on adjacent commercial farms in the north-east, east and south-east of Zimbabwe (Mason and Norval, 1980).

The only known vectors of *B. bigemina* and *B. bovis* in Africa are ticks of the genus *Boophilus* of which two species occur in Zimbabwe, *Boophilus decoloratus* and *Boophilus microplus*. *B. decoloratus* is an African tick which is distributed throughout the country while *B. microplus* is an Asian tick that thas recently spread into the country from Mozambique (Mason and Norval, 1980). *B. microplus* is a vector of *B. bigemina* and *B. bovis* (Callow, 1979) and until recently it was generally believed that the same was true for *B. decoloratus*. However, studies in South Africa (Potgieter, 1977; de Vos, 1979) have revealed that *B. decoloratus* does not transmit *B. bovis*. There is no cross-immunity between *B. bovis* and *B. bigemina* and although transovarian transmission occurs in both diseases their developmental cycles in the tick are different. *B. bovis* is transmitted during the larval feeding period (Potgieter and Els, 1976; Potgieter and van Vuuren, 1974) whereas *B. bigemina* is transmitted during the nymphal and adult feeding periods (Potgieter, 1977; Potgieter and Els, 1977). Another epidemiologically important difference between the diseases is that *B. bovis* will only be transmitted from one generation of ticks to the next if adult female ticks feed on infected hosts while *B. bigemina* can be transmitted through several generations of ticks in the absence of re-infection (Potgieter and Els, 1977; Callow, 1979).

To assess the present day distribution and incidence of the two *Babesia* species a serological and tick survey was carried out on young cattle at centres throughout the country. The results have been related to the history of disease and dipping in each area and conclusions are drawn on methods of control of babesiosis in the future.

MATERIALS AND METHODS

Serum and tick samples were collected between April 1980 and April 1981 at 274 localities throughout Zimbabwe (216 in communal farming areas and 58 on commercial farms). At each locality blood was taken from approximately 30 calves aged from one to three years and total tick collections were made from five of these animals. To obtain accurate assessments of the size of infestations the animals were restrained on the ground and carefully searched for engorged and engorging adult female ticks. Cattle owners were questioned about the disease and dipping history of the herds sampled and further information on these subjects was obtained from locally based government veterinary officials.

The serum separated from the clotted blood and the ticks were kept in cool conditions and transported to the laboratory within five days of collection. At the laboratory sera were preserved at −20°C prior to serological testing. Ticks were preserved in 70% ethanol and later identified using a stereo microscope.

The indirect fluorescent antibody test (Ross and Löhr, 1968) was used for detection of specific antibodies to both *Babesia* species. Antigen slides were prepared by infecting a splenectomised calf with a field strain of *B. bigemina* and another with a vaccine strain of *B. bovis* from the Veterinary Research Institute at

Onderstepoort, South Africa. When parasitaemias of 8 to 12% were observed 20 ml of venous blood was drawn from each calf into 200 ml phosphate buffered saline (PBS) (pH 7·2). After three washings in PBS the cells were re-suspended in PBS to yield a packed cell volume of 25%. Smears were prepared, air dried and fixed in cold acetone for 10 min. Slides were dried, wrapped in tin foil and stored at −20°C. Testing was carried out at room temperature after slides had been thawed at 4°C for 1 h.

All serum samples were diluted at 1/40 in PBS and simultaneously screened against *B. bigemina* and *B. bovis* at this dilution. Rabbit antibovine conjugate Cat. No. 65-614-2 (Miles Laboratories, Slough, UK) was used at a dilution of 1/40.

RESULTS

Figure 1 compares the frequency of cattle in communal and commercial farming areas which exhibit antibody titres to *B. bigemina* and *B. bovis* of 40 or more. Antibodies to *B. bigemina* were very much more common in the communal areas. At 58% of localities in these areas more than 80% of sera tested were positive for *B. bigemina* as compared with 24% of commercial farms. On the majority of commercial farms (43%) antibodies to *B. bigemina* were detected in less than 20% of sera. Similar low percentages of *B. bigemina* positives were only recorded at a few

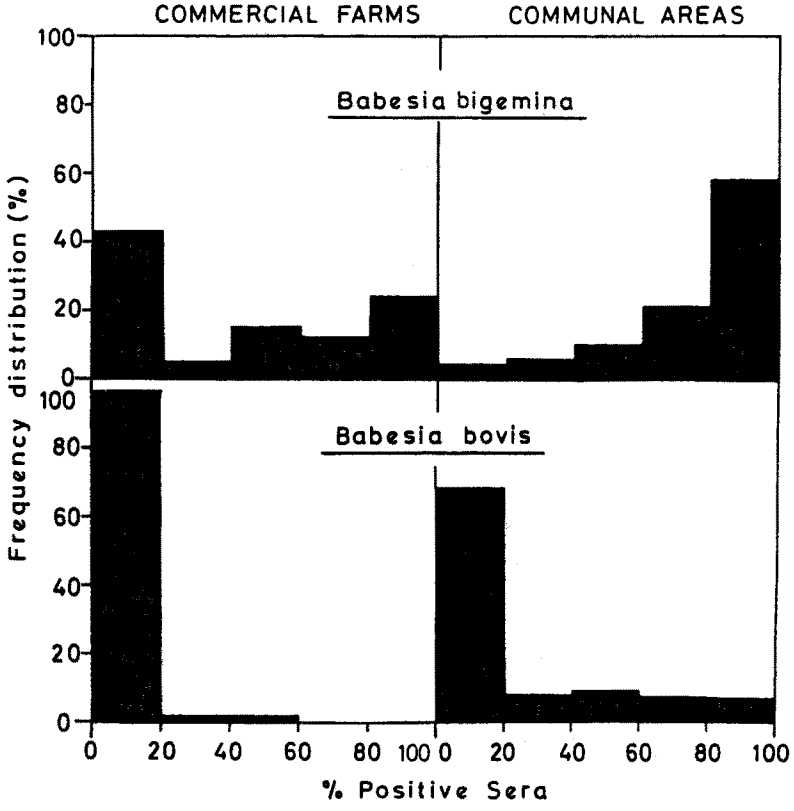

FIG. 1. Occurrence of serological positives for *Babesia bigemina* and *Babesia bovis* on commercial farms and in communal farming areas in Zimbabwe.

localities (5%) in the communal areas. No serological positives for *B. bigemina* were recorded from 14 localities (24%) in the commercial areas and only two localities (0·5%) in the communal areas.

The incidence of *B. bovis* was very much lower. Antibodies to the disease were detected in more than 80% of sera at only 7% of localities in communal areas and at no localities in the commercial farming areas. At 97% of localities in commercial areas less than 20% of sera were positive for *B. bovis*. No serological positives for *B. bovis* were recorded from 47 localities (81%) in the commercial areas and from 101 localities (47%) in the communal areas.

Owners' reports of cattle deaths in the year prior to the survey together with the diagnostic findings of the Department of Veterinary Services indicated that clinical babesiosis occurred most frequently at localities where the percentage of serological positives for either *B. bigemina* or *B. bovis* was in the range 21 to 60%. Babesiosis did not appear to be a significant cause of cattle mortality at localities where no *Babesia* antibodies were detected or where the percentage of serological positives was over 80%.

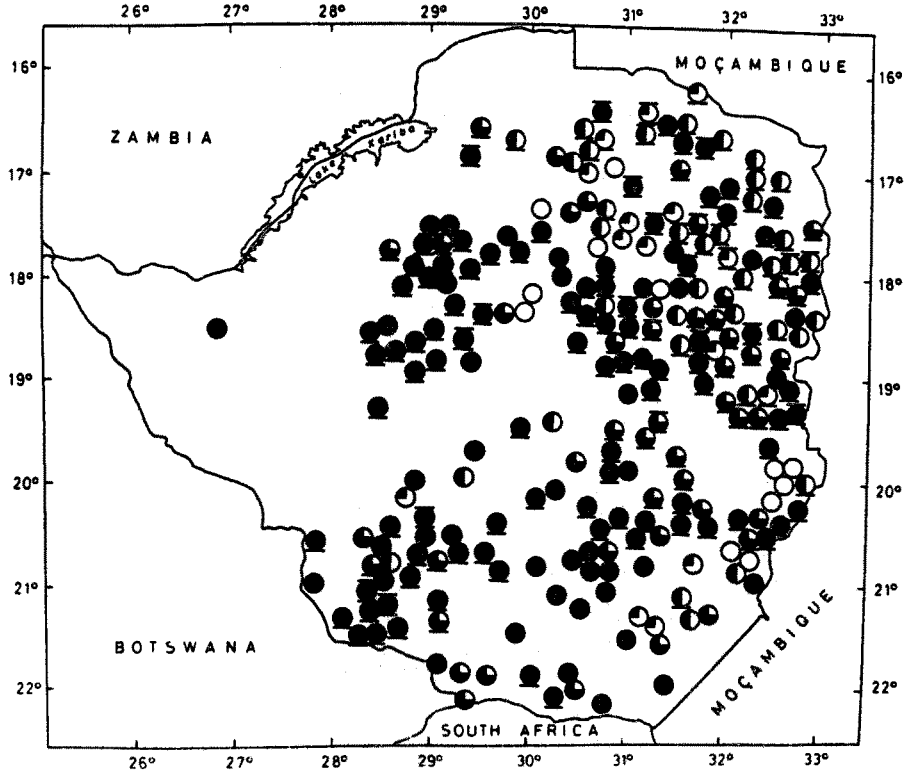

FIG. 2. Epidemiological status of *Babesia bigemina* and the distribution of *Boophilus* spp. in Zimbabwe. Circles represent localities at which sera and ticks were collected: ●, 81 to 100% positive sera; ◕, 61 to 80% positive sera; ◐, 21 to 60% positive sera; ◔, 1 to 20% positive sera; ○, 0% positive sera. A line below a circle indicates that *Boophilus* spp. were collected at that locality. Lines above and below a circle indicates that cattle were heavily infested with *Boophilus* spp. (+20 engorging adult females per animal). The map shows 242 of the 274 localities sampled (localities have been omitted where several circles would have overlapped).

On the basis of the frequency of occurrence of serological positives and disease history five different epidemiological situations were defined.

1. Enzootically stable situations (81 to 100% positive sera).
2. Situations approaching enzootic stability (61 to 80% positive sera).
3. Enzootically unstable situations (21 to 60% positive sera).
4. Minimal disease situations (1 to 20% positive sera).
5. Disease-free situations (0% positive sera).

By using different symbols to represent each epidemiological situation the occurrence and epidemiological status of *B. bigemina* and *B. bovis* throughout Zimbabwe were mapped (Figs 2 and 3). The maps also show the occurrence and abundance of the vectors, *Boophilus* spp. (Fig. 2) and *B. microplus* (Fig. 3).

B. bigemina and its vectors (*Boophilus* spp.) were recorded from all climatic zones in Zimbabwe. In communal areas *B. decoloratus* was collected from 58% of localities sampled and *B. microplus* from 26%, whereas in commercial areas *B. decoloratus* was collected from only 9% of localities sampled and *B. microplus* from

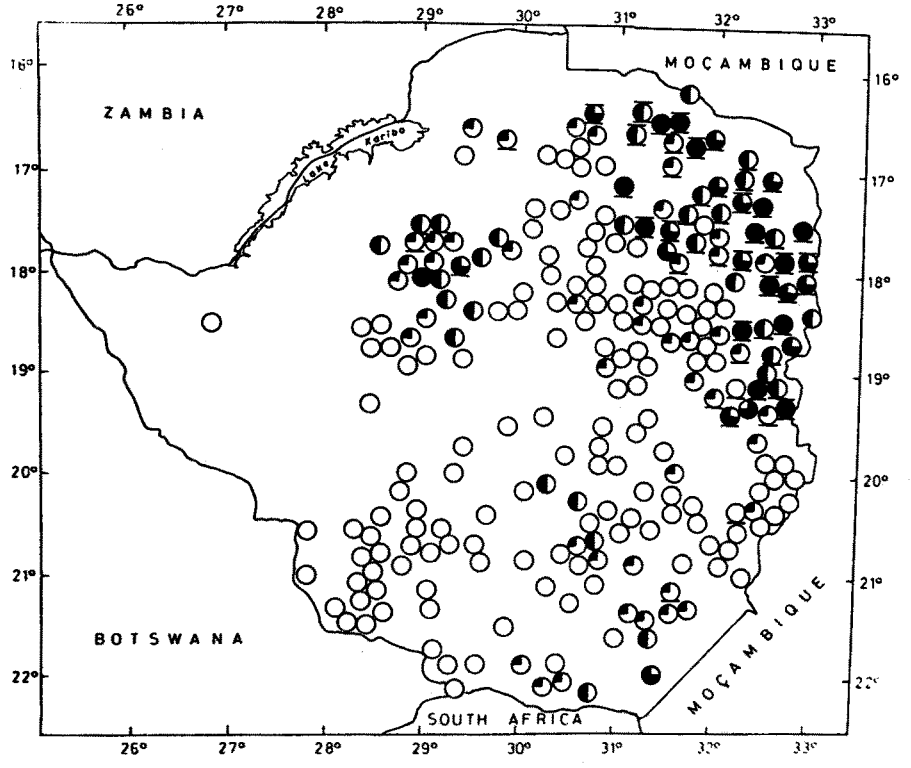

FIG. 3. Epidemiological status of *Babesia bovis* and the distribution of *Boophilus microplus* in Zimbabwe. Circles represent localities at which sera and ticks were collected: ●, 81 to 100% positive sera; ◕, 61 to 80% positive sera; ◐, 21 to 60% positive sera; ◔, 1 to 20% positive sera; ○, 0% positive sera. A line below a circle indicates that *B. microplus* was collected at that locality. Lines above and below a circle indicates that cattle were heavily infested with *B. microplus* (+20 engorging adult females per animal). The map shows 242 of the 274 localities sampled (localities have been omitted where several circles would have overlapped).

only 3%. The absence of the ticks from cattle on most commercial farms was associated with regular dipping. Where dipping had re-started in communal areas cattle were also largely free of *Boophilus* spp. Disease-free and minimal disease situations for *B. bigemina* occurred most commonly on commercial farms in the higher rainfall eastern half of the country. Enzootic instability was also recorded most frequently in the higher rainfall areas particularly in the north-east. Enzootic stability predominated throughout the drier western half of the country.

The distribution of *B. bovis* followed closely that of its vector *B. microplus* which was well established in the north-east (northern and eastern Mashonaland) and east (Manicaland) of the country and was also present at a few localities in the south-east (Chiredzi and Chipinge districts) and north-west (Gokwe district). With the exception of one locality in the Gokwe district, enzootic stability for *B. bovis* was only recorded in north-eastern and eastern Zimbabwe where *B. microplus* was most abundant. Even in these areas, however, there were a number of localities which were not enzootically stable despite the presence of *B. microplus*. The Gokwe district also had many localities that were unstable. In the Chiredzi district in the south-east *B. microplus* appeared to be only tenuously established as it was collected at only one centre and it is probably for this reason that enzootic stability was not evident in the area. Low numbers of *B. bovis* serological positives were recorded at several localities outside the distribution range of *B. microplus*. However, no *B. bovis* positives were recorded from south-western Zimbabwe which is a considerable distance away from the main foci of infection. In two instances *B. microplus* was collected from localities from which none of the sera tested was positive for *B. bovis*.

DISCUSSION

Before dipping was introduced in Zimbabwe enzootic stability for *B. bigemina* probably existed in all cattle herds and it was only susceptible imported stock that died from the disease. Dipping resulted in the suppression or localised eradication of *B. decoloratus* and this must have disrupted enzootic stability in many herds. On the majority of commercial farms disease-free or minimal disease situations now exist and it appears that enzootic stability has only persisted on properties where tick control is poor. Disease-free or minimal disease situations probably also existed in most communal areas in the eastern half of the country before the disruption of dipping. Enzootic stability has subsequently been re-established in many of these areas but at the cost of large numbers of cattle deaths. In the drier southern and western parts of Zimbabwe enzootic stability has probably always existed despite dipping.This would explain why cattle deaths as a result of *B. bigemina* infection did not occur here after the disruption of dipping in the 1970s and why people believed that the disease was absent from these parts of the country. A probable reason for the persistence of enzootic stability in low rainfall areas is that dipping in these areas usually stops during the dry season (May to November) due to lack of water. The cessation of dipping for all or part of the dry season is probably sufficient to ensure the continuity of the life cycle of *B. decoloratus* which is not seasonally regulated (Mason and Norval, 1980) and the transmission of *B. bigemina* to all calves.

The correlation between the distribution of *B. bovis* and *B. microplus* confirms that this tick is the main and probably the only vector of *B. bovis* in southern Africa. The present distribution of *B. microplus* leaves little doubt that the tick spread into Zimbabwe from Mozambique. Because of the disruption of dipping and uncontrolled cattle movements during the war it is now widely distributed in eastern Zimbabwe.

The presence of *B. microplus* in the Gokwe district was not detected in a previous survey which was terminated in 1979 (Mason and Norval, 1980) indicating that the tick has only recently been introduced into the area. The fact that in two instances *B. microplus* was collected at localities on the periphery of its distributional range where no serological positives for *B. bovis* were recorded is evidence for the continuing spread of the tick in eastern Zimbabwe. At all other localities at which *B. microplus* was collected the presence of *B. bovis* was confirmed. Cattle movements probably account for the occurrence of low numbers of *B. bovis* serological positives outside the distributional range of *B. microplus*. However, it is possible that the occurrence of *B. bovis* antibodies in cattle is an indication that *B. microplus* is or has been present in an area. The tick only remains on a host for about three weeks whereas antibodies persist for several years (de Vos, pers. comm.) so serology provides a more sensitive indicator of the presence of *B. microplus* than any tick collecting techniques.

Although the epidemic spread of *B. bovis* caused heavy cattle mortality, enzootic stability for the disease now exists at some localities. Surprisingly, though, enzootically unstable situations exist at several localities where *B. microplus* appears to be well established and which are stable for *B. bigemina*. Although a possible explanation for this is that stability for *B. bigemina* exists because of the presence of *B. decoloratus*, Mason and Norval (1980) noted that in Zimbabwe *B. microplus* competes with and replaces *B. decoloratus*. It is therefore unlikely that *B. decoloratus* will be present where *B. microplus* is well established. Another possibility is that infection rates in *B. microplus* larvae are higher with *B. bigemina* than with *B. bovis* because *B. bigemina* is able to pass through several generations of ticks in the absence of re-infection while *B. bovis* is not. A further anomaly concerning the *B. microplus* areas is that enzootic instability for *B. bigemina* appears to occur more frequently in these areas than in the rest of the country (Figs 2 and 3). This could indicate that *B. bigemina* is transmitted less efficiently by *B. microplus* than it is by *B. decoloratus* and is worthy of further investigation.

The findings of this survey in general conform with those of similar, more limited surveys carried out in South Africa (de Vos, 1979; de Vos and Every, 1981) and are of considerable value in that they provide a scientific basis for planning future strategies for the control of babesiosis in Zimbabwe. Of particular importance is the knowledge that enzootic stability for *B. bigemina* is widespread in communal areas especially those in the drier parts of the country; enzootic stability for *B. bigemina* does not exist on the majority of commercial farms; enzootic stability for *B. bovis* is restricted to a few localities in communal areas and the occurrence of this disease is dependent on the presence of *B. microplus*. Specific recommendations that can be made in the light of this knowledge are that short-interval dipping throughout the year should not be practised in communal areas if enzootic stability for *B. bigemina* is to be maintained; where it is necessary to dip regularly for the whole year (to control other species such as *Rhipicephalus appendiculatus*) cattle in both communal and commercial areas should be vaccinated against *B. bigemina*; cattle should be vaccinated against *B. bigemina* before moving from one farm or area to another; in areas where *B. microplus* is established cattle should be vaccinated against *B. bovis* as should cattle being moved into these areas.

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EPIDEMIOLOGIE DES MALADIES DES BOVINS TRANSMISES PAR LES TIQUES AU ZIMBABWE. I. BABESIOSE

Résumé—Une enquête sur l'incidence des anticorps de *Babesia bigemina* et *Babesia bovis* chez des veaux âgés de 1 à 3 ans dans 274 localités du Zimbabwe a révélé que *B. bigemina* était présente dans tout le pays avec pour vecteur principal *Boophilus decoloratus*. La répartition de *B. bovis* suivait de près celle de son vecteur *Boophilus microplus* qui est limité à la partie est du pays. La stabilité enzootique pour *B. bigemina* a été notée dans la plupart des régions d'élevage traditionnel où le traitement des bovins par bains détiqueurs a été interrompu depuis plusieurs années; mais elle était moins courante dans les fermes industrielles où ces bains sont pratiqués régulièrement. La stabilité enzootique pour *B. bovis* était réduite à quelques localités des régions d'élevage traditionnel et le parasite était rare dans les fermes industrielles.

EPIDEMIOLOGIA DE LAS ENFERMEDADES TRANSMITIDAS POR GARRAPATAS EN ZIMBABWE. I. BABESIOSIS

Resumen—Se llevó a cabo un estudio de a incidencia de anticuerpos de *Babesia bigemina* y *Babesia bovis*, en terneros en edades comprendidas entre uno y tres años, en 274 localidades de Zimbabwe. Los resultados revelaron, que *B. bigemina* existe en todo el pais conjuntamente con su vector principal, *Boophilus decoloratus*. La distribuición de *B. bovis* siguió aquélla de su vector *Boophilus microplus*, el cual existe únicamente en la parte oriental del pais. La estabilidad enzoótica de *B. bigemina* fué notoria en la mayoria de regiones en donde los baños garrapaticidas habían sido interrumpidos por varios años. En las regiones en donde se practicaban baños regulares en fincas comerciales, ésta fué menos manifiesta. La estabilidad enzoòtica de *B. bovis* estuvo restringida a unas pocas localidades de pastoreo comunal y la presencia de parásitos fué rara en fincas o hatos comerciales.