Tropical Animal Health and Production, 33 (2001) 117–125

Transmission of *Theileria parva* in the Traditional Farming Sector in the Southern Province of Zambia during 1997–1998

M. Mulumba[1], N. Speybroeck[1,2], D.L. Berkvens[2], D.M. Geysen[2] and J.R.A. Brandt[2]*
[1]*ASVEZA South, Veterinary Research Station, PO Box 670500, Mazabuka, Zambia;*
[2]*Prince Leopold Institute of Tropical Medicine, Department of Animal Health, Nationalstraat 155, B-2000 Antwerp, Belgium*
**Correspondence: E-mail: jbrandt@itg.be*

Mulumba, M., Speybroeck, N., Berkvens, D.L., Geysen, D.M. and Brandt, J.R.A., 2001. Transmission of *Theileria parva* in the traditional farming sector in the Southern Province of Zambia during 1997–1998. *Tropical Animal Health and Production*, **33(2)**, 117–125

ABSTRACT

The incidence of first contact with the protozoan *Theileria parva* was determined in two traditional cattle herds in the Southern Province of Zambia during a period of average rainfall in 1997 and 1998, following a drought in the previous two years. Compared to that period, there was a marked increase in the number of rainy season first contacts attributable to transmission by *Rhipicephalus appendiculatus* adults. However, there were still more dry season contacts that resulted from nymphal transmission. These results highlight the important role that climate plays in the transmission of theileriosis in the Southern Province of Zambia.

Keywords: cattle, epidemiology, *Rhipicephalus appendiculatus*, season, stadia, *Theileria parva*, transmission

Abbreviations: EDTA, ethylenediaminetetraacetic acid; IFAT, indirect fluorescence antibody test; ZCA, Zambia College of Agriculture

INTRODUCTION

Bovine theileriosis is a protozoan infection caused by parasites that belong to the genus *Theileria* (Bettencourt *et al.*, 1907). The most important species occurring in Eastern, Central and Southern Africa is *Theileria parva*. This parasite is transmitted mainly by the ixodid tick *Rhipicephalus appendiculatus* and causes an often fatal, lymphoproliferative disease of cattle. The transmission of the disease is transtadial, with larvae and nymphs picking up the infection and transmitting it in their next stage of development as nymphs and adults, respectively. The records of the Department of Veterinary and Tsetse Control Services in Zambia show that the first case of theileriosis (in this paper *T. parva* infection) in the country was recorded at Fife (now Nakonde) in the Northern Province in 1922 and then in Lundazi, Eastern Province in 1927. For a long time, the disease remained confined to these two provinces (Sempebwa-Serugo, 1976) but in

1970 and 1972 two outbreaks were reported near Lusaka in Chisamba, Central Province (Anon., 1974). The first documented case of the disease in Southern Province was at Hufwa, in Monze district, in 1978 (Chizyuka and Mangani, 1985) when the disease caused considerable losses in cattle in the traditional sector. The epidemiology of bovine theileriosis in the Southern Province of Zambia is complex, with the nymphal stage of *R. appendiculatus* playing a more significant role in the transmission of the disease than was previously thought (Mulumba *et al.*, 2000). In addition, the number of strains of *T. parva* capable of causing disease in cattle, which are known to have existed or to still exist in the province (Geysen *et al.*, 1999), further complicate the attainment of endemic stability against the disease. F. Musisi was the first to isolate three *T. parva* stocks, ZAM2, ZAM3 and ZAM5, in the province in 1982. Other stocks were isolated later (Nambota *et al.*, 1997). In an attempt to better understand the epidemiology of the disease in the province, a series of studies involving close follow-up of sentinel herds was undertaken. In an initial study, it was shown that, contrary to widespread belief, larva-to-nymph transmission played a more significant role than nymph-to-adult transmission, reinforcing our hypothesis that climate was the major driving force behind the disease pattern in the province (Mulumba *et al.*, 2000). That study was, however, carried out during a period of partial drought and it was thus not possible to tell whether this was a regular feature of the disease pattern. Therefore, it was decided to extend the study in order to monitor the disease over a longer period and so acquire a better understanding of the epidemiological pattern. This paper presents results for the 1997–1998 period.

MATERIALS AND METHODS

Study area

The Southern Province of Zambia lies between latitudes 15° 14′S and 17° 42′S and longitudes 25°E and 28°E. Monze district is located in the centre of the province, while Gwembe district forms part of the eastern boundary of the province. The unimodal rainfall lasts from November to April on the plateau (Monze) and October to February in the valley (Gwembe). The annual rainfall range is 400–600 mm in the valley and 700–1100 mm on the plateau. Much of the *Brachystegia* (Miombo) and *Acacia* (Muunga) woodlands on the plateau have been cut down to pave the way for cultivation of crops, while *Colophospermum mopane* (Mopane) and scrub woodland predominate in the valley (Mulofwa *et al.*, 1994).

One sentinel herd at Nteme in Monze (16° 10′S, 27° 29′E; 1050 m) and another at Halubilo in Gwembe (16° 26′S, 27° 42′E; 780 m) were studied. Follow-up of another herd at Keemba in Monze district was discontinued in early 1997 following the death of the farmer and the continual reduction in the number of cattle left in the herd after translocation of most of the animals to the Kafue flats. In the Nteme herd, there were 21 animals at risk at the beginning of 1997 and 30 at the beginning of 1998. In the Halubilo herd, 49 animals were at risk at the beginning of 1997 and 31 at the start of 1998. The sampling frame consisted of all the animals carried over from the previous

study (Mulumba *et al.*, 2000) that had not yet come into contact with *T. parva* and subsequent newborn calves. Seventeen and 18 newly born calves were recruited into the Nteme herd in 1997 and 1998, respectively. Three newly born calves were added to the herd in Halubilo in 1997. Tick control was not practised in either herd. The predominant cattle type on the plateau is the indigenous Sanga, while the traditional Tonga breed (*Bos indicus* type) is more common in the valley.

Sampling

A weekly sampling routine for both herds was maintained during the two years. Rainfall and temperature data were obtained from the Zambia College of Agriculture (ZCA) in Monze (Figures 5 and 6). At every visit, venous blood from the animals in the sampling frame was collected into EDTA vacuum blood tubes (Terumo, Belgium). Cool boxes lined with ice packs were used to store the blood until it reached the laboratory, where blood smears were prepared from each sample. Ear-vein blood smears and needle biopsies from the parotid and prescapular lymph nodes of animals showing signs of illness were prepared on the spot in the field. The smears were fixed in methanol and stained with Giemsa. The Veterinary Assistants were provided with motorcycles to enable timely transport of samples collected from sick animals to the laboratory for immediate diagnosis. The indirect fluorescent antibody test (IFAT) for serum antigen was carried out according to the method described by Burridge and Kimber (1972). Refinements made to the serological test allowed a cut-off titre of 1/160 to be used when using schizont antigen compared to the 1/40 cut-off that was used in the first study by Mulumba and colleagues (2000). This cut-off ensured a high specificity of the test but implies a lower sensitivity. For the duration of the study, calves were treated with albendazole (Verbazin) four times at 6-month intervals. The monthly abundances of nymph and adult instars were similar to those reported by MacLeod (1970) and by Mulumba and colleagues (2000). Larvae were most abundant from March to April.

Data management

Only animals that came into contact with *T. parva* in 1997 and 1998 were included in the present analysis. Their dates of birth and dates of contact were recorded. Contact was taken as the first appearance of a serotitre of 1/160 (Burridge and Kimber, 1972) or above for at least four consecutive weeks. Calves showing serotitres of 1/160 and above when less than 3 months old were, however, excluded from the analysis because of difficulties in differentiating between seropositive titres resulting from maternal immunity (Moll and Lohding, 1984) and real first contact with *T. parva*. Eight such calves were identified and excluded from the analysis.

Data analysis

Data analysis was carried out in Stata Statistical Software 1998: Release 6.0 (Stata Corporation, College Station).

RESULTS

Frequency distributions for the month of birth and month of first contact with *T. parva* are shown in Figures 1 and 2, respectively. Figure 3 shows the month of first contact as a function of the month of birth and Figure 4 shows the number of adult and nymphal *R. appendiculatus* on the adult cattle in each month. Calving was not uniform throughout the year (χ^2 = 53.1, df = 10, $p<0.05$), there being a concentration of calvings at the start of the rainy season, peaking in January, and ending with a smaller peak during the cool dry season. The hypothesis of equiprobability of first contacts throughout the year was not rejected (χ^2 = 17.1, df = 10, $p<0.1041$), indicating lack of a clear-cut seasonal pattern in the incidence of first contact. Contacts were spread throughout the year, with apparent peaks in the cool dry season (May to August) and in the rainy season months of January and February. There were 70 animals at risk at the beginning of the study in January 1997. Twenty-two animals came into contact during the year, while 20 calves were born and recruited into the study in the same period. Four animals were lost to follow-up before coming into contact during the year. Sixty-one animals were at risk at the beginning of 1998. During the year, 26 animals came into contact while 56 were lost to follow-up before coming into contact or were

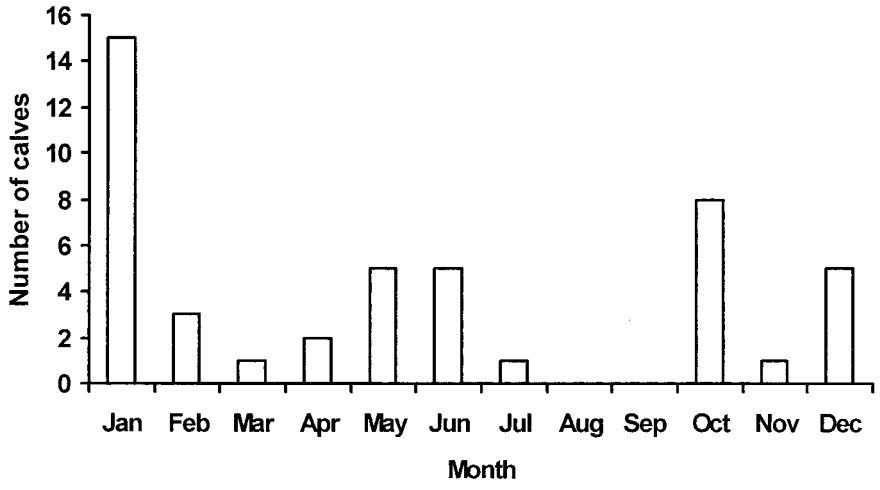

Figure 1. Frequency distribution of the month of birth of calves in Southern Zambia

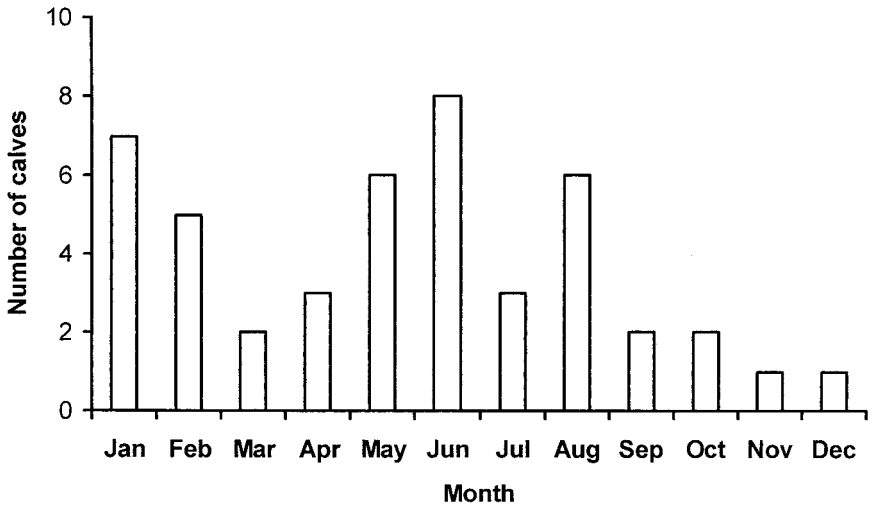

Figure 2. Frequency distribution of the month of first contact with *Theileria parva* by calves in Southern Zambia during 1997–1998

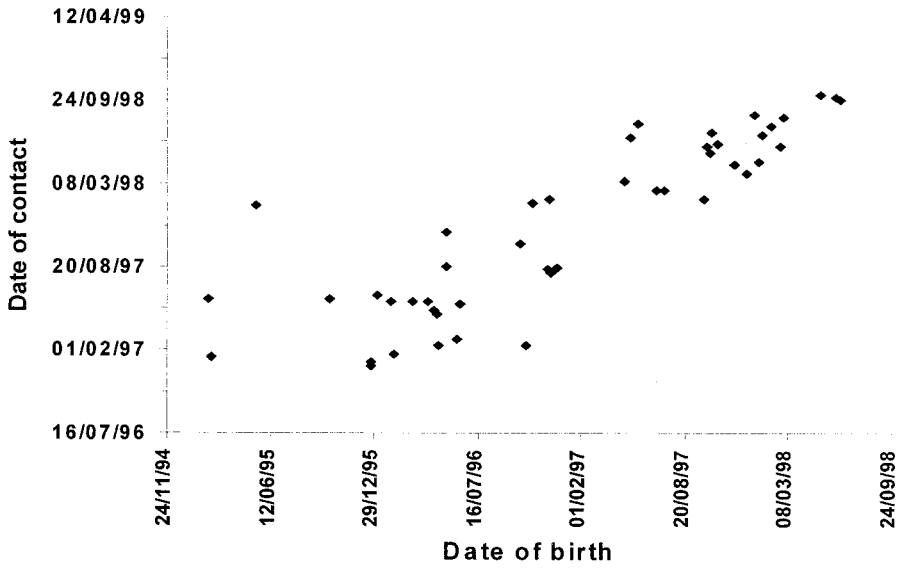

Figure 3. Month of first contact with *Theileria parva* as a function of the month of birth for calves in Southern Zambia during 1997–1998

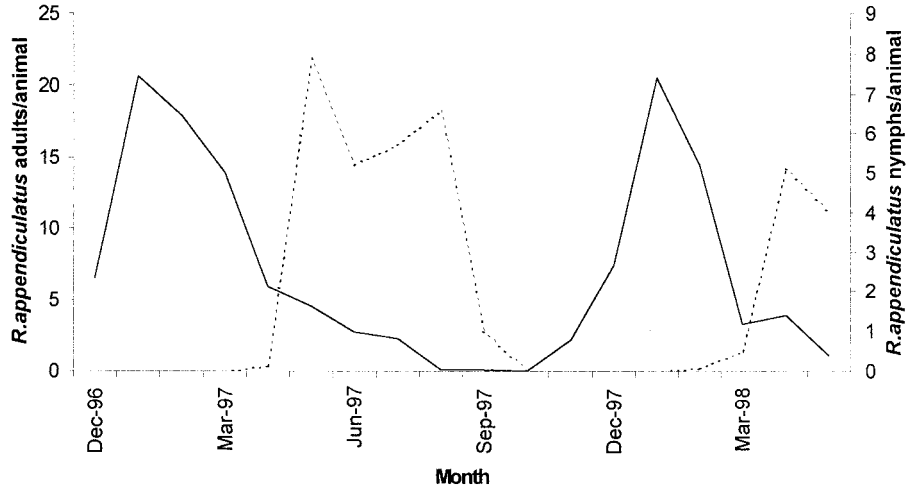

Figure 4. Average monthly *R. appendiculatus* counts in the sentinel herd for 1997–1998: — adults per animal; .... nymphs per animal

excluded at the end of the study. Figure 5 shows the rainfall pattern for the period 1995–98. Compared with the 1995–96 period, there was a notable increase in the amount of rainfall recorded during 1997–98. Figure 6 shows the temperatures in Monze district for 1997 and 1998.

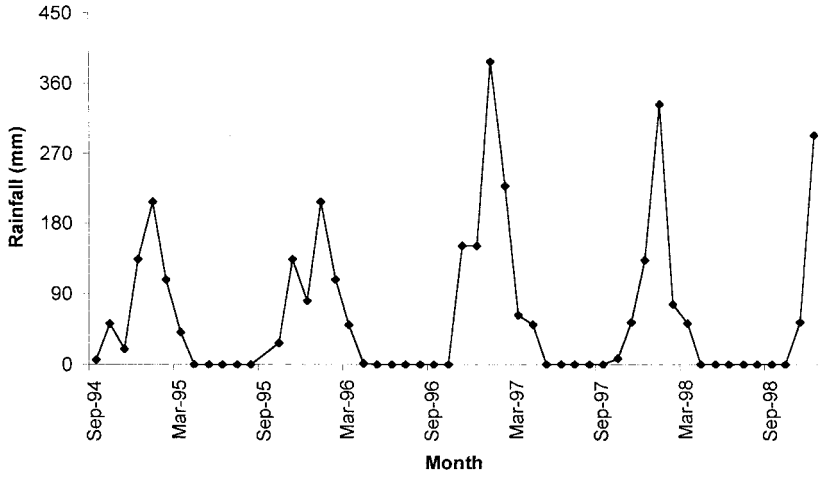

Figure 5. Rainfall distribution in Southern Zambia for the period September 1994–December 1998

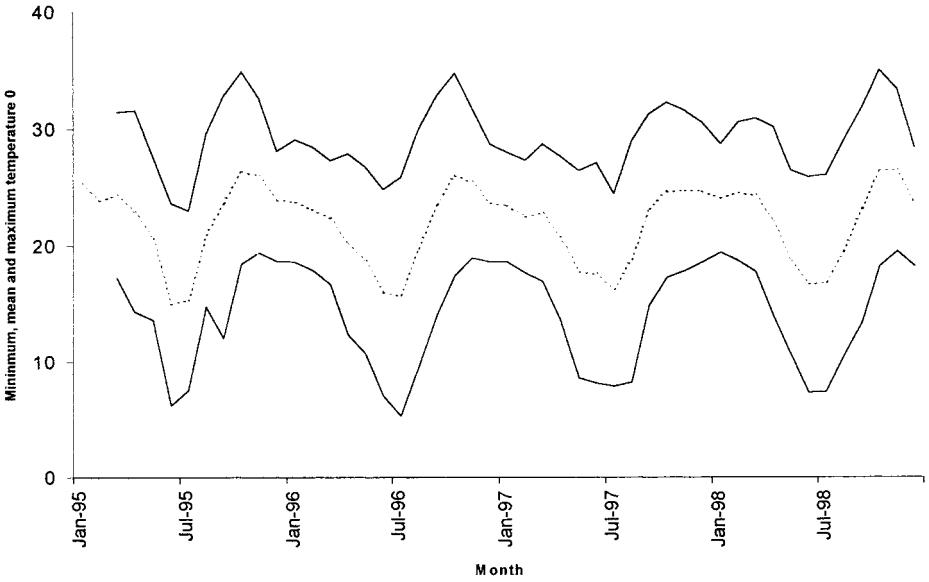

Figure 6. Monthly temperatures in Monze district for the period January 1995–December 1998

DISCUSSION

This study was a continuation of that carried out in 1995–96 (Mulumba *et al.*, 2000), which had indicated that the *T. parva* infection pattern in the province was mainly influenced by larva-to-nymph transmission and was therefore concentrated in the cool, dry season, when *R. appendiculatus* nymphs are abundant (see Figures 4, 5 and 6) (MacLeod, 1970; Mulumba *et al.*, 2000). Compared to the 1995–96 study, the main feature of the current study was the significant increase in the number of cases occurring in the rainy season, which were associated with the activity peak of *R. appendiculatus* adults and therefore with nymph-to-adult transmission. Although there was no statistically significant difference in monthly incidence, there is now a suggestion of a bimodal incidence pattern, rather than the unimodal pattern observed during the drought of 1995–96 (Mulumba *et al.*, 2000). This is noteworthy because, apart from the exclusion of Keemba from the current study, most of the other factors remained the same as in the first study, except for the obvious difference in the amount of rainfall recorded between the two periods of study (Figure 5). Against this background, it is tempting to suggest that the increased rainfall during the period 1997–98 was responsible for the improved efficiency of nymph-to-adult transmission. A possible explanation for why nymphal challenge (Figure 2) remained high is that the infection levels were higher in the animals during the rainy season, so that larvae picked up higher infections during March and April, which they then transmitted as nymphs in the cool dry season.

While acknowledging the existence of a bimodal pattern of *T. parva* infection in the Southern Province, the Epidemiology Unit of the Veterinary Department, in its monthly reports, has often reported a higher incidence of the disease in the rainy season followed by a small second peak between March and July (see summary in Nambota *et al.*, 1994). A second peak in the dry season was also reported in the Eastern Province, where it was shown by Berkvens and colleagues (1998) to be due to a second generation of *R. appendiculatus* adults, and in Northern province, where it was attributed to larva-to-nymph transmission (Nambota *et al.*, 1994). Even in the drought years of 1991 and 1992, a similar picture was reported (Nambota *et al.*, 1994). It is difficult to say whether the findings of this present study reflect a true reversal of the intensities of the different instar transmissions of the disease. It may be that what was observed was a return to the traditional disease pattern previously recorded in the Southern Province.

It is intended that a thorough discussion of other possible biotic and abiotic factors influencing the transmission dynamics of *T. parva* in the Southern Province of Zambia will form the subject of a further paper in an attempt to explain the difference in patterns of contact between the two periods of observation.

REFERENCES

Anon., 1974. Annual Report of the Department of Veterinary Services and Tsetse Control, Lusaka

Berkvens, D.L., Geysen, D.M., Chaka, G., Madder, M. and Brandt, J.R.A., 1998. A survey of the ixodid ticks parasitising cattle in the Eastern Province of Zambia. *Medical and Veterinary Entomology*, **12**, 234–240

Bettencourt, A., Franca, C. and Borges, I., 1907. Addendum â nota sôbre piroplasmose dô gamo. *Revista de Medicina Veterinaria Lisbon*, **6**, 37–40

Burridge, M.J. and Kimber, C.D., 1972. The indirect fluorescent antibody test for experimental East Coast fever (*Theileria parva* infection of cattle): evaluation of a cell culture schizont antigen. *Research in Veterinary Science*, **13**, 451–455

Chizyuka, H.G.B. and Mangani, M.P.C., 1985. Theileriosis in Zambia. In: A.D. Irvin (ed.), *Immunization against Theileriosis in Africa: Proceedings of a Joint Workshop*, Nairobi, 1–5 October 1984, (International Laboratory for Research on Animal Diseases, Nairobi)

Geysen, D., Bishop, R., Skilton, R., Dolan, T.T. and Morzaria, S., 1999. Molecular epidemiology of *Theileria parva* in the field. *Tropical Medicine and International Health, Supplement*, **4**, A21–A27

MacLeod, 1970. Tick infestation patterns in the Southern Province of Zambia. *Bulletin of Entomological Research*, **60**, 253–274

Moll, G. and Lohding, A., 1984. Epidemiology of theileriosis in the Trans-Mara division, Kenya: husbandry and disease background and preliminary investigations on theileriosis in calves. *Preventive Veterinary Medicine*, **2**, 801–831

Mulofwa, J., Simute, S. and Tengnas, B., 1994. *Agro-forestry – Manual for Extension Workers in Southern Province of Zambia*, (SIDA Regional Soil Conservation Unit)

Mulumba, M., Speybroeck, N., Billiouw, M., Berkvens, D.L., Geysen, D.M. and Brandt, J.R.A., 2000. Transmission of theileriosis in the traditional farming sector in the Southern Province of Zambia during 1995–1996. *Tropical Animal Health and Production*, in press

Nambota, A., Samui, K., Sugimoto, C., Kakuta, T. and Onuma, M., 1994. Theileriosis in Zambia: etiology, epidemiology and control measures. *Japanese Journal of Veterinary Research*, **42**, 1–18

Nambota, A., Lovelace, C.E.A., Chitambo, H., Kakuta, T., Sugimoto, C. and Onuma, M., 1997. Characterization of some *Theileria parva* stocks from Zambia using monoclonal antibodies. *Journal of Veterinary Medical Science*, **59**, 1–4

Sempebwa-Serugo, C.M., 1976. Theileriosis in Zambia. In: J.B. Henson and M. Campbell (eds), Report of a Workshop held in Nairobi, Kenya, 7–9 December 1976

(Accepted: 18 February 2000)

Transmission de *Theileria parva* dans un système agricole traditionnel entre 1997 et 1998 dans la province du sud de la Zambie

Résumé – l'incidence du premier contact antigénique avec le protozoaire *Theileria parva* fut déterminée dans deux troupeaux élevés de façon traditionnelle dans la province sud de la Zambie pendant une période de pluies moyennes en 1997 et 1998, après 2 années de sécheresse. Pendant cette période il y eut une augmentation notable des premiers contacts avec *T. parva* pendant la saison des pluies ceci étant dù aux formes adultes de *Rhipicephalus appendiculatus*. Cependant il y eut plus de contacts pendant la saison sèche et ceci dù aux nymphes. Ces résultats soulignent l'importance que joue le climat dans la transmission de la theileriose dans la province sud de la Zambie.

Transmisión de *Theileria parva* en el sector granjero tradicional de la provincia del sur de Zambia durante 1997–1998

Resumen – La incidencia del primer contacto con el protozoo *Theileria parva* se determinó en dos rebaños tradicionales de ganado vacuno, en la provincia del sur de Zambia durante un período habitualmente lluvioso en 1997 y 1998, tras un período de aridez en los dos años anteriores. Comparado con ese período, se observó un marcado aumento en el número de primeros contactos durante la estación lluviosa, atribuible a la transmisión de *Rhipicephalus appendiculatus* adultos. Sin embargo, había todavía un mayor número de contactos en la estación seca, debido a la transmision por ninfas. Estos resultados destacan la importancia del rol que juega el clima en la transmision de theileriosis en la provincia del sur de Zambia.