The absence of clinical disease in cattle in communal grazing areas where farmers are changing from an intensive dipping programme to one of endemic stability to tick-borne diseases

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ABSTRACT

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A two-year field study was conducted in four communal grazing areas in South Africa. Sera were collected from young cattle (6–18 months old) in these areas during the winters of 1991 to 1993. The sera were tested for antibodies to *Babesia bovis, Babesia bigemina, Anaplasma marginale* and *Cowdria ruminantium*. In two of the four areas, treatment with acaricide was erratic and dependent on the discretion of individual owners. In these areas the drought of 1992 had a major impact on tick burdens and there were changes in the seroprevalence to tick-borne diseases. In the other two areas there was a reduction in the intensity of acaricide application and this was associated with an increase in seropositivity to the tick-borne diseases. Increases in the prevalence of seropositivity and the presence of endemic instability, as calculated from inoculation rates, were not accompanied by outbreaks of clinical disease. Possible reasons for this are discussed.

Keywords: Absence of clinical disease outbreaks, *Anaplasma marginale, Babesia bigemina, Babesia bovis*, communal grazing areas, *Cowdria ruminantium*, endemic stability, tick-borne diseases of cattle

INTRODUCTION

Ticks and tick-borne diseases (TBDs) are a significant cause of loss to cattle owners in communally grazed areas in Southern Africa (Norval 1981; Norval, Perry & Hargreaves 1992). The losses occur as mortality and morbidity from TBD as well as tick worry and abscessation, which result in production losses.

Control of ticks on cattle in communally grazed areas generally takes one of two forms. A dip tank may be available and is run by the Government's animal health service with the farmers paying a levy per head of cattle. This is subsidized to varying extents depending on the area. Alternatively there is no dip tank, or it is not maintained adequately and each farmer controls the ticks on his cattle in his own way. If there is a dip tank available and it is functioning the cattle are usually dipped efficiently (once every 7–14 days) and the majority of animals are presented on dipping days. These cattle tend to have low tick burdens and are believed to be in an endemically unstable state, with most being susceptible to tick-borne disease (Norval 1979; Norval, Perry & Hargreaves 1992; Norval, Barret, Perry & Mukhebi 1992).

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If no functioning dip tank is available each owner controls ticks on his cattle independently of the others. Acarcides are usually administered as hand sprays, pour-ons and tick grease in response to what the owners consider to be excessive tick burdens. Cash availability and accessibility of retail outlets for the purchase of acaricide are major limiting factors. The cattle of these owners often carry high tick burdens and are likely to be in an endemically stable state. Tick control in this form, in response to what are considered excessive burdens, is known as threshold or tactical dipping (Walker 1990).

Principle of endemic stability

The principle of endemic stability to TBDs was first mooted by Mahoney & Ross (1972) in Australia, using *Babesia bovis* in *Boophilus microplus* as an example. They stated that if the inoculation rate of the protozoa by the tick into cattle is sufficiently high, then all calves would be infected whilst still protected by age resistance. Clinical disease would be minimal and endemic stability would be achieved. If, however, the inoculation rate is not sufficiently high, calves would not be immunized before they lose their age resistance and clinical cases would result. With low tick numbers disease transmission is interrupted, resulting in minimal disease.

Mahoney & Ross (1972) also developed a model, which relates the infection rate, or the proportion of animals infected (I), measured by serological surveys on animals of known age (t), to the inoculation rate (h). The relationship is given by the following formula (Mahoney & Ross 1972): $I = 1 - e^{ht}$

For the *Boophilus microplus—Babesia bovis* system Mahoney & Ross (1972) found that in endemically stable situations for *Bos taurus* cattle, the inoculation rate ranged from 0,05–0,005. Minimal disease did not occur until a rate of < 0,0005 was reached. The Food and Agriculture Organisation (1984) recommend that serological surveys of animals of known age be undertaken, from which inoculation rates are then calculated.

Such principles have been difficult to apply in communal grazing areas in southern Africa, where a variety of tick species and diseases have to be considered. However, despite these difficulties, there are many proponents of the view that it is better to aim for endemic stability to TBD in communal areas in Africa rather than practise intensive acaricidal treatment (Norval 1981; Norval, Fivaz, Lawrence & Daillecourt 1983; Pegram & Chizyuka 1991; Norval, Perry & Hargreaves 1992; Norval, Barret, Perry & Mukhebi 1992).

Alternatively, supporters of intensive acaricidal application point out that the high tick burdens that are necessary for endemic stability result in significant production losses as a result of reduced immunity to disease, abscessation and blood loss (Ardington 1982; Bartlett 1982; Taylor & Plumb 1981). Additionally, endemic stability for babesiosis, anaplasmosis and heartwater can be difficult to achieve or to maintain if, for any reason, there is a decrease in tick numbers (De Vos 1979; Ardington 1982).

Mahoney & Ross (1972) state that 90% of the herd need to be seropositive in order to generate endemic stability to *B. bovis.* Attempts have been made to determine inoculation rates for *B. bovis* in southern Africa. De Vos & Potgieter (1983) found no clinical disease on farms where less than 20% of the cattle had seroconverted to *B. bovis*. At seroconversion prevalence rates of 20–70%, there was endemic instability and the presence of clinical disease. Farmers with more than 70% of animals seropositive reported less clinical disease although they were not entirely free from clinical cases.

Serological surveys for *B. bigemina* in Zambia (Jongejan, Perry, Moorhouse, Musisi, Pegram & Snacken 1988) and in South Africa (De Vos & Potgieter 1983) yielded inoculation rates that were in the unstable range but that were not always associated with clinical disease. Norval, Fivaz, Lawrence & Daillecourt (1983), in their survey of babesiosis in communal lands in Zimbabwe, defined five epidemiological situations as follows:

	% positive sera
Disease free situation	0
Minimal disease with cattle dipped frequently and few ticks	1–20
Endemically unstable with frequent disease outbreaks	21–60
Approaching endemic stability	61–80
Endemic stability	81–100

The level of endemic stability for *B. bigemina* and *B. bovis* on individual commercial farms in relation to dipping strategy and tick burdens has been investigated by several authors. Ardington (1982) found that strategic dipping resulted in light *Boophilus decoloratus* infestations, but these failed to maintain endemic stability to *B. bigemina.* In a survey in the Natal midlands De Vos & Every (1981) noted that endemic instability for *B. bigemina* was related to the use of plunge dips and that on the majority of those farms that used spray races, the tick numbers were higher and as a result endemic stability to *B. bigemina* was achieved. They also concluded that endemic stability for *B. bigemina* was a consequence of poor tick control. With moderate control, where *Boophilus* spp. were detectable, there was endemic instability in all areas. Good tick control, where virtually no adult ticks were present on the cattle, resulted in reduced seroconversion prevalence rates, to fewer than 10% in certain areas.

In southern Africa, the regions where there is endemic instability to anaplasmosis were found to be those on the margins of the distribution areas of the *Boophilus* spp. ticks (Potgieter 1979). The degree of stability for anaplasmosis was not correlated to dipping frequency in trials in Namibia (Biggs & Langehoven 1984). Norval, Fivaz, Lawrence & Brown (1983), in their serological survey in Zimbabwe, found a greater number of *Anaplasma marginale* reactors in areas where the tick challenge was highest, but dipping did not appear to significantly reduce the number of seropositive animals.

In southern Africa, there are endemic regions where there are sufficient numbers of *Amblyomma hebraeum* to provide situations that are endemically stable for *Cowdria ruminantium,* unless they are interfered with by tick control (Bezuidenhout & Bigalke 1987). Epidemics occur where conditions are marginal for the survival of the ticks. In these circumstances, *A. hebraeum* is normally absent but encroaches at times, particularly if the rains are good. Intensive tick control is recommended to control heartwater in such areas (Bezuidenhout & Bigalke 1987). In a study involving 23 farms in heartwater areas in South Africa, Du Plessis & Malan (1987) found that the percentage of calves seropositive for heartwater was correlated to tick burdens and dipping intensity. In addition, changes in dipping frequency have been found to have a profound effect on the prevalence of seropositivity (Du Plessis, Locke & Ludemann 1992).

MATERIALS AND METHODS

The present study was conducted between June 1991 and August 1993, with the aim of determining the impact of acaricidal application on the TBDs in the following four communally grazed areas in South Africa:

Rietgat

Rietgat is a semi-rural village situated in the Odi 1 District of the North West Province of South Africa. The cattle population surveyed consisted of 153 cattle belonging to 17 owners. The cattle grazed 748 ha on a communal basis. Thirty sheep and 60 goats also used the communal grazing.

The area was generally overgrazed, with *Aristida congesta,* subsp. *congesta* and *Eragrostis rigidior* grasses predominating. There was evidence of bush encroachment by *Dichrostachys cinera* subsp. *africana, Acacia caffra* and *Acacia karoo.* The quality of the grazing improved as the distances to the village increased.

On average, the cattle owners claimed to dip their cattle 2,4 times a month in the summer and 1,6 times a month in the winter. However, management problems led to the discontinuation of the dip tank's use and to a decrease in acaricide concentration to insignificant levels by February 1992.

Madinyane

Madinyane and Ramogatla are two contiguous rural villages that share a communal grazing area, situated in the same Odi 1 District. The cattle population surveyed, consisted of 800 cattle, divided amongst 40 owners. The cattle grazed 4820 ha on a communal basis. Fifty sheep and 595 goats also used the grazing area. The grazing was not divided into camps but the owners live on 5 ha plots and use the grazing as they see fit, on an individual basis. No rotational grazing of the communal herd was practised. The communal grazing area was more extensively overgrazed than that of Rietgat. A dip tank had never been available in this area. Instead, owners individually used a variety of methods to control ticks on their cattle.

Bethany

The grazing area is situated next to the village of Modikwe which is 5 km north-west of Bethany in the Odi 2 District of the North West Province of South Africa. The cattle were managed as a single herd and 250 large stock units were kept on 2000 ha. The area is divided into 16 camps and a rotational grazing system was practised. A dip tank had been used for tick control efficiently and effectively every 2 weeks since the system's inception in 1980 until the end of 1992, when the management of the tank and dipping broke down.

Geluk

Geluk is a rural area in the Eerstehoek District in the Mpumalanga Province of South Africa. The cattle population consists of 810 head, divided amongst 54 owners. The cattle graze on 3600 ha on a communal basis. The area was not divided into camps. No rotational grazing of the communal herd was practised, although cattle were often herded into the mountains (north-eastern mountain sourveld) in the winter in search of grazing. The grazing was also used by 811 goats, 112 sheep, 77 donkeys and 28 horses. A dip tank had been used efficiently and effectively almost every week since 1975.

Prior to 1975, the local cattle population would have been dipped weekly by the resident farmers, in compliance with East Coast fever control regulations. Since the beginning of 1992, a dipping levy had been charged. Cattle belonging to owners who had not paid the levy were excluded from the dip tank. The result was that there was a drop in dipping rates from 71,4% in 1991 to 60% in 1992 and 55% in 1993.

Serological screening of the cattle populations

Blood samples were taken once a year on inspection days between June and August in 1991, 1992 and 1993 at Rietgat and Madinyane. At Geluk and Bethany, the cattle were blood sampled between June and August in 1992 and 1993. As many calves as possible, between the ages of 6 and 18 months, were sampled and the approximate age of the sampled cattle was recorded. A record of the age of each animal was not taken in Geluk in 1992. Inoculation rates (h) were calculated using the folowing equation:

$$h = \frac{\log(1 - I)}{t}$$

where I = the average proportion of seropositive animals; and

t = the mean age of the animals sampled

The proportions of samples seropositive in the different years were compared to each other using the two tail Fisher's exact test.

Serological laboratory tests

Babesia bovis and *B. bigemina* antibodies were assayed by the indirect fluorescent antibody test (Joyner, Donnelly, Payne & Brocklesby 1972), as described by Gray & De Vos (1981). The assay was considered positive if the titres exceeded 1/80.

Anaplasma marginale antibodies were assayed by the competitive inhibition (CI) ELISA (Knowles, Perryman, Kappmayer & Hennager 1991). *Cowdria ruminantium* antibodies were assayed by the indirect ELISA test (Voller, Bartlett & Bidwell 1978; Sumption, Ghebremichael, Paxton, Soldan, Norman & Edelston 1993).

RESULTS

The serological results from all four areas are summarized in Table 1 and the inoculation rates in Table 2.

TABLE 1 Results of serological surveys for antibodies in cattle to the TBDs in Rietgat, Madinyane, Bethany and Geluk in 1991, 1992 and 1993

Age of cattle in months	Seropositive/total sample											
	1991				1992				1993			
	6–8	9–12	13–18	Total %	6–8	9–12	13–18	Total %	6–8	9–12	13–18	Total %
Area and species												
Rietgat												
B.bovis	7/20	2/9	2/2	35	0/7	1/21	1/15	5	0/0	1/5	3/18	17
B.bigemina	18/18	9/9	2/2	100	1/7	12/20	9/16	51	0/0	5/5	10/13	83
A..marginale	13/14	3/5	1/1	85	1/1	5/9	6/6	75	0/0	5/5	13/13	100
C. ruminantium	5/18	3/7	0/2	30	5/7	15/19	10/13	77	0/0	5/5	12/13	94
Madinyane												
B. bovis	9/9	16/18	3/3	93	1/3	0/2	0/0	20	12/22	12/23	6/6	59
B. bigemina	7/9	9/18	3/3	63	1/3	0/2	0/0	20	20/22	12/23	6/6	74
A.marginale	5/7	2/9	1/1	47	1/3	0/2	0/0	20	22/22	21/23	6/6	96
C. ruminantium	2/7	4/16	0/3	23	–[a]	–	–	–	18/22	20/23	5/6	84
Bethany												
B. bovis	–	–	–	–	2/41	0/4	0/3	4	0/20	2/31	0/1	4
B. bigemina	–	–	–	–	3/41	0/5	0/3	6	2/20	1/31	0/1	6
A. marginale	–	–	–	–	15/42	2/2	1/3	38	4/20	23/31	0/1	52
C. ruminantium	–	–	–	–	7/41	0/4	0/3	15	13/20	28/31	1/1	81
					6–18 months							
Geluk												
B. bovis	–	–	–	–	4/80			5	5/11	4/16	8/15	40
B. bigemina	–	–	–	–	17/79			22	10/11	13/16	13/15	86
A. marginale	–	–	–	–	9/29			31	7/11	9/16	11/15	64
C. ruminantium	–	–	–	–	24/82			29	8/11	8/16	13/15	69

[a] Not tested

TABLE 2 Inoculation rates of B.bovis and B. bigemina in Rietgat, Madinyane, Bethany and Geluk in 1991, 1992 and 1993

Year	1991		1992		1993			
Area	Rietgat	Madinyane	Rietgat	Bethany	Rietgat	Madinyane	Bethany	Geluk
Inoculation rate								
B. bovis	0,0015	0,0089	0,00042	0,00017	0,00042	0,0033	0,00013	0.0015
B. bigemina	> 0,02	0,0044	0,0042	0,00026	0,0042	0,01	0,00022	0,0057

Serological findings

The changes in the specific prevalence of animals seropositive to *B. bovis, B. bigemina, A. marginale* and *C. ruminantium* in 1991, 1992 and 1993 in the four areas are recorded in Table 1. The inoculation rates calculated for *B. bovis* and *B. bigemina* are recorded in Table 2.

Rietgat

Seroprevalence to *B. bovis* was low in 1991 and remained low throughout the study. In 1991, the seroprevalence for *B. bigemina* in cattle in the Rietgat area was high (100%) but this dropped significantly ($P < 0,05$) in 1992 to 51%. This represented a passage to instability with the inoculation rate falling from above 0,02 in 1991 to 0,0042 in 1992. In 1993, the seroprevalence rose significantly ($P < 0,05$) to 83% with an inoculation rate of 0,0042 and a passage back towards endemic stability. No clinical cases or deaths from TBDs were reported from the communal grazing in Rietgat in 1992, 1993 and early 1994. Seroprevalence to *A. marginale* and *C. ruminantium* was high throughout the study.

Madinyane

Animals were within the unstable range for *B. bigemina* in 1991 and *B. bovis* in 1993. In addition, there were significant rises ($P < 0,05$) in seroprevalence to *A. marginale* and *B. bigemina* between 1991 and 1993. However, only one case of TBD (redwater) was reported during this period.

Bethany

The seroprevalence of *B. bovis* and *B. bigemina* was much lower than in the other areas. A significant ($P < 0,05$) increase in the seroprevalence to *C. ruminantium* occurred and an increase in the number of *A. hebraeum* males on the cattle was observed following a reduction in the dipping intensity between 1992 and 1993. No clinical cases of heartwater were reported.

Geluk

In Geluk there were significant ($P < 0,05$) increases in the prevalence of seropositivity between 1992 and 1993 for both *B. bovis* and *B. bigemina*. This was considered to be the consequence of an increased rainfall and the reduced dipping intensity in 1993, which led to to the appearance of *B. decoloratus* on both cattle and goats.

The inoculation rate was in the stable range (Mahoney & Ross 1972) for *B. bigemina*, but remained in the unstable range for *B. bovis*. However, no clinical cases of redwater were reported. Significant ($P < 0,05$) increases in the prevalence of seropositivity for *A. marginale* and *C. ruminantium* also occurred at Geluk between 1992 and 1993, but no clinical cases were reported.

DISCUSSION

The important findings of this study are as follows:

Cattle populations at Rietgat moved from endemic stability to *B. bigemina* infection to instability then back towards stability and the passage from endemic stability to instability should have resulted in clinical disease (Mahoney & Ross, 1972; Mahoney 1977). The cattle populations at Madinyane appeared to be in a state of instability for *B. bigemina* in 1991 and *B. bovis* in 1993. At Bethany there was a significant increase in the seroprevalence to *C. ruminantium*. At Geluk there were significant increases in seroprevalence of all four species with the inoculation rate for *B. bovis* remaining in the unstable range for the two years of the study.

Despite these findings, however, there were no outbreaks of clinical disease recorded. The reasons for this anomaly are probably complex but the following factors may have played a role.

The strains of the organisms involved may have been relatively non-pathogenic. This has been cited as a reason for the absence of clinical cases of anaplasmosis and babesiosis in supposedly unstable situations elsewhere (James, Coronado, Lopez, Melendes & Ristic 1985; Jongejan, Perry, Moorhouse, Musisi, Pegram & Snacken 1988). This may be the case in *B. bigemina* infections, but is unlikely to be so with *B. bovis*, which is generally a more pathogenic organism (Brown, Hunter & Luckins 1990). Variation in strain pathogenicity is also recorded for heartwater and anaplasmosis (Uilenberg 1990). In addition, the increase in seroprevalence to *C. ruminantium* may have been due to cross reactions with the non-pathogenic *Ehrlichia* spp. as been described by Du Plessis, Camus, Oberem & Malan (1987).

Norval (1979) stated that after the collapse of dipping in many parts of Zimbabwe, which occurred during and after the pre-independence war, outbreaks of babesiosis usually followed in the second rainy season after the cessation of dipping. This is presumably because the infection rate in the ticks takes 2 years to build up to levels high enough to cause transmission and outbreaks of disease. However, in Bethany and Geluk, the presence of seropositive animals indicates that transmission was occurring following the reduction in dipping intensity during the study period and clinical disease should have occurred in some non-immune animals.

Local cattle in the project areas may have been resistant to TBDs after years of exposure as has been observed elsewhere (Uilenberg 1990). Disease surveillance by the veterinarians, animal health officers and stock inspectors in the four areas may have been inadequate and this could have resulted in clinical cases and deaths not being reported. However, cattle owners are very sensitive to outbreaks of acute disease with mortality in their cattle and these are usually reported rapidly. Cases of chronic or mild transient disease may not have been reported and this may have occurred in the innately resistant *Bos indicus* cattle, which make up the bulk of the population in the study areas.

Another possible factor is the presence of bias in the sampling methods which meant that the cattle tested were not representative of the cattle populations, leading to inaccuracies. Ideally, every calf in each of the four populations should have been sampled. Unfortunately, this was not possible for logistical reasons, although it was noted that the owners who presented the cattle for blood sampling each year were the same. This implies that the cattle population from which the samples were taken were unlikely to have changed over the study period.

CONCLUSION

The study indicated that the cattle populations passed from endemic instability and a low prevalence of seropositivity to endemic stability and a high prevalence of seropositivity, without disease. Further work needs to be done to determine whether this is a repeatable finding under South African conditions. Should it be repeatable, the findings have considerable implications for veterinarians who design and implement tick control strategies in communally grazed areas.

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