



Tick diversity, abundance and seasonal dynamics in a resource-poor urban environment in the Free State Province

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ABSTRACT

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The objectives of this study were to determine the diversity, seasonal dynamics and abundance of ticks infesting cattle in urban, small-scale farming communities in and around Botshabelo and Thaba Nchu in the eastern Free State Province, South Africa. A total of ten cattle, ear-tagged for individual identification, were investigated monthly at each of five localities. Adult ticks were removed from the right hand side of each animal and placed in containers filled with 70% ethanol. They were subsequently identified and their numbers quantified. Immature *Otobius megnini* were counted but not removed. A total of 244 538 adult ticks of ten different species were collected over the 12-month study period. The tick species, in decreasing order of relative abundance, were: *Boophilus decoloratus* (87,26%), *Rhipicephalus evertsi evertsi* (6,86%), *Hyalomma marginatum rufipes* (2,42%), *Otobius megnini* (1,85%), *Rhipicephalus foliis* (0,76%), *Rhipicephalus gertrudae* (0,54%), *Rhipicephalus* sp. (0,21%), *Ixodes rubicundus* (0,08%), *Hyalomma truncatum* (0,01%) and *Margaropus winthemi* (0,004%). The three most abundant species, namely *B. decoloratus*, *R. evertsi evertsi* and *H. marginatum rufipes*, occurred at all localities but with significant differences in abundance. *M. winthemi* ticks occurred only in the Thaba Nchu area and were not found at any of the three localities in Botshabelo. Significant differences in tick burdens between the six warm months (September to February) and the six cooler months (March to August) were found for most of the species recorded. *Boophilus decoloratus* occurred in significantly higher numbers in autumn (March to May) and winter (June to August) compared to spring (September to November) and summer (December to February), with 76,8% of the total *B. decoloratus* burden occurring during the cooler months.

Keywords: Cattle, seasonal dynamics, tick diversity, ticks, urban environment

INTRODUCTION

Improved animal health is a vital component in the development of cattle production in South Africa. Tick infestations and tick-borne diseases are the most widespread of all the major livestock problems in Africa (Dipeolu, Mongi, Punyua, Latif, Amoo & Odhiambo 1992).

Production losses due to ticks and tick-borne diseases therefore pose important and significant impediments to improved animal health (Van Rensburg 1981).

Various integrated tick management plans have been advocated, but an integrated approach has to be based on as full a knowledge as possible of the natural constraints to tick and tick-borne disease organism life cycles. The estimates of the economic damage caused, and the costs of control measures, must also be taken into consideration (Tatchell 1992). Accurate information on tick ecology, such as geographical distribution and seasonal variations in numbers,

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is thus required (Pegram, Perry, Musisi & Mwanaumo 1986).

Many different tick species have been identified in southern Africa, and the use of acaricides dates back to the turn of the century (Norval 1994). Most commercial livestock farmers in South Africa make use of acaricides in tick management programmes. In contrast, the resource-poor small farmers on tribal and communal lands do not readily spend money on any form of stock improvement, including the use of acaricides (Dreyer 1997). The absence of regular acaricide use in the Botshabelo and Thaba Nchu areas of the Free State Province in South Africa has presented a unique opportunity to collect tick census data on untreated cattle, and to study the dynamic relationships which exist between ticks, their hosts, the diseases they transmit and the environment. Such information is important in the planning of tick management programmes and the investigation of alternative means of control (Londt, Horak & De Villiers 1979).

The primary objective of this study was to obtain information on the diversity of tick species infesting cattle under a traditional management system in the Botshabelo and Thaba Nchu areas. Further objectives were to quantify the seasonal dynamics, abundance and distribution of the various tick species within the study areas.

MATERIALS AND METHODS

Study area

The study was carried out from September 1995 to August 1996 in two urban areas in the south-eastern Free State Province of South Africa, namely Botshabelo and Thaba Nchu, which are located 55 and 65 km east of Bloemfontein, respectively. At both locations small-scale cattle farming is practised in urban or peri-urban areas under resource-poor conditions.

Three different groups of cattle in and around Botshabelo (29°12'–29°18'S; 26°40'–26°45'E), were used in the study. These were at Block W on the western periphery (referred to as Botshabelo-west), Block C on the eastern periphery (referred to as Botshabelo-east) and Block K in the centre of Botshabelo (referred to as Botshabelo-middle). Cattle from each block normally grazed in the specific region concerned. Cattle in Block K grazed in the large open areas within the city. Two groups of cattle from two semi-rural villages, situated within a radius of 7 km of Thaba Nchu, were also included in the study. Motlatla (29°10'S; 26°47'E) is located towards the north and Victoria Neck (29°15'S; 26°47'E) towards the south of Thaba Nchu. Each village has its own communal grazing area. The different areas were specifically selected to include groups of cattle whose

grazing or environment differed, e.g., cattle grazing within an urban environment (Botshabelo-middle), those grazing on urban outskirts in large open grassveld areas (Botshabelo-west), those grazing on hilly, rocky outskirts (Botshabelo-east) and cattle kept in more traditional village management systems, including the grassveld of Motlatla and the rocky outcrops of Victoria Neck.

Topography and altitude

The largest part of the central Free State highveld is flat and situated at an altitude between 1 200 and 1 500 m above sea-level. The flatness of the area is occasionally broken by loose standing koppies (small hills) and ridges, as well as rivers and streams flowing from east to west, the eastern area being of higher altitude (1 500–1 800 m) (Mostert, Roberts, Hellinga & Coetzee 1971). Botshabelo and Thaba Nchu are located towards the eastern region.

Climate

The central Free State is a summer rainfall region. The mean annual rainfall in the east ranges from 560–650 mm and progressively decreases from the east to the west across the Free State Region (Mostert *et al.* 1971). Rainfall was recorded at the Bloemfontein Airport meteorological station, as well as at the municipal offices of Botshabelo and Thaba Nchu. Thaba Nchu is situated to the east of Botshabelo, thus at a higher altitude with a slightly higher rainfall. The highest monthly rainfall for the region was recorded in February 1996 and the lowest in June 1996 (Fig. 1a). The daily minimum and maximum atmospheric temperatures were recorded at the meteorological station at Bloemfontein Airport, located 55 km from Botshabelo (Fig. 1b).

Cattle management

Cattle are kept under small-scale farming systems in which an average of 9,34 ($\pm 0,8$) head are owned per farmer (Dreyer 1997). During the day the cattle graze on the communal pastures, usually for 6–9 h per day, determined by the time of year. In the evenings, cattle are herded and the lactating cows milked. They are kept overnight in kraals covered with manure in the backyards of their owners.

Experimental animals

The cattle in the area are all of mixed-breed origin with predominantly Friesian crosses in Botshabelo and Brown Swiss crosses in Thaba Nchu. The study animals were all older than 12 months and included both sexes. A total of 10 animals, ear-tagged for individual identification, were investigated monthly at each of the five localities. Farmers participating in the study themselves used no acaricides on their cattle during the 12-month study period.

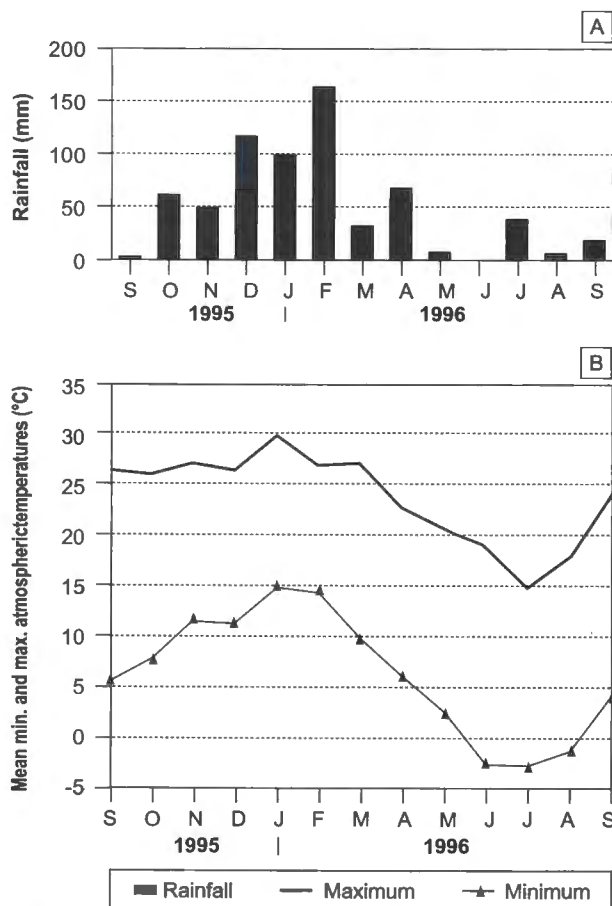


FIG. 1 The monthly rainfall (mm) recorded for the general study area (a), and the mean monthly maximum (—) and minimum (—) atmospheric temperatures (°C) for the study period (b)

Tick sampling procedures

During the tick collecting procedure the animals were individually restrained in a mobile handling facility. Adult ticks in all stages of engorgement were collected from the right-hand sides of the hosts. The only immature stages identified and counted *in situ* were those of *Otobius megnini* in the ear canals. Adult ticks were located visually or by means of palpation with the palm of the hand and by running fingers through the hair coat on the body of the cattle. The ticks were removed with forceps and placed in labelled plastic containers filled with 70% alcohol. During periods of high tick infestations, the left sides of the study animals were also hand sprayed with Amitraz (Triatrix Cattle Spray, Hoechst Ag-Vet), after the ticks on their right sides had been collected.

Tick identification and counts

Tick identifications were verified by comparing them with reference specimens in the collection of the Department of Zoology and Entomology, University of

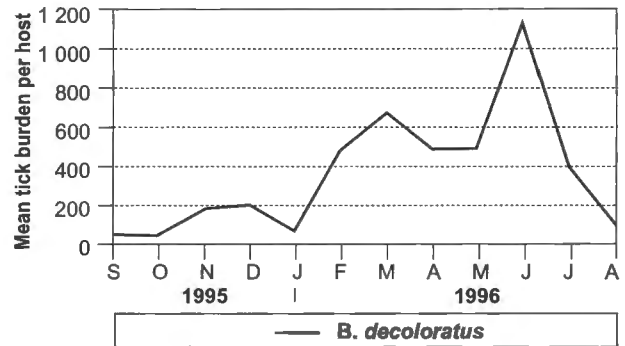


FIG. 2 Mean monthly *Boophilus decoloratus* burdens per host ($n = 50$) during the 12-month study period (September 1995 to August 1996). Data combined for the five study localities

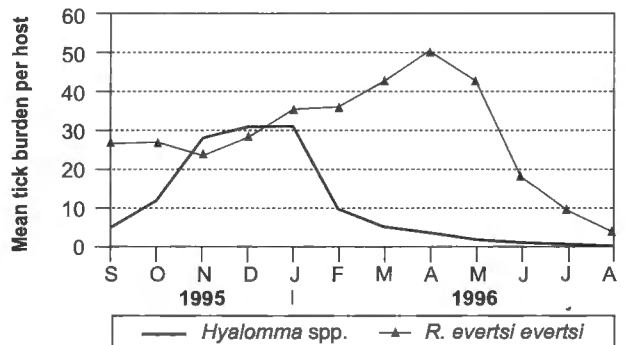


FIG. 3 Mean monthly *Hyalomma* spp. and *Rhipicephalus evertsi evertsi* burdens per host ($n = 50$) during the 12-month study period (September 1995 to August 1996). Data combined for the five localities

the Free State, Bloemfontein. The number of ticks collected from each animal was doubled to give an indication of the total tick burden on each animal. The only ticks identified and counted *in situ* were the larvae and nymphs of *O. megnini* in the ear canal.

Data presentation and analysis

The data sets were analyzed statistically using the appropriate analysis of variance techniques. The software programme SPSS Release, version 4.0 for Convex UNIX was employed. Logarithmic transformations of all the tick burdens were done in order to achieve normality and equality of variances for parametric testing. An unpaired Student *t*-test was used to compare burdens of the different tick species between the six warmer months (September to February) and six cooler months (March to August). A one-way analysis of variance (ANOVA) (Barnard, Gilbert & McGregor 1993) was used to determine significant differences between spring (September to November), summer (December to February), autumn (March to May) and winter (June to August) burdens

of *Boophilus decoloratus*. This was followed by a multiple range procedure, namely the Least Significant Difference (LSD) test, to indicate the seasons causing the variance (Zar 1974).

A significance level of $P \leq 0,05$ was used throughout.

RESULTS

Diversity, relative abundance and distribution

A total of 244 538 ticks of 10 different species were recorded during the 12-month period.

These species, in decreasing order of relative abundance, were: *B. decoloratus* (87,26%), *Rhipicephalus evertsi evertsi* (6,86%), *Hyalomma marginatum rufipes* (2,42%), *O. megnini* (1,85%), *Rhipicephalus follis* (0,76%), *Rhipicephalus gertrudae* (0,54%), *Rhipicephalus* sp. (0,21%), *Ixodes rubicundus* (0,08%), *Hyalomma truncatum* (0,01%) and *Margaropus winthemi* (0,004%) (Table 1).

The mean burden of *B. decoloratus* per host was $359,22 \pm 23,03$. Burdens of this species were so high at times that skin changes such as alopecia, flaking, scaling and crust formation, occurred at the various predilection attachment sites. The mean burdens per host of *R. evertsi evertsi* and *H. marginatum rufipes* were $28,23 \pm 1,09$ and $9,96 \pm 0,73$ respectively.

The three most abundant species, *B. decoloratus*, *R. evertsi evertsi* and *H. marginatum rufipes*, occurred at all of the five localities, but with significant differences in abundance (Table 2). *Ixodes rubicundus* and *H. truncatum* were not found in Botshabelo-middle (Block K) and Motlatla, respectively. No *M. winthemi* ticks were found at any of the three localities in Botshabelo and only occurred at the two near Thaba Nchu (Table 2).

Seasonal dynamics

Significant differences in tick burdens for the six warm months (September to February) and the six cooler months (March to August) were found for most of the species recorded (Table 3).

Boophilus decoloratus occurred in significantly higher numbers in autumn and winter (March to May and June to August) compared to spring and summer (September to November and December to March), with 76,8% of the total tick burden occurring during the cooler months. Monthly population fluctuations ranged from $41,30 \pm 4,93$ adult *Boophilus* ticks per animal during the low-tick season to $1\,133,32 \pm 40,10$ during the high-tick season (Fig. 2). Findings on *I. rubicundus* also revealed significantly higher numbers during the cooler months (98,98%) (Table 3).

In contrast to the above-mentioned species, *H. m. rufipes*, *H. truncatum*, *O. megnini*, *R. gertrudae* and *R. follis* also showed great seasonal variations, but with significantly higher tick burdens in the warmer months (September 1995 to February 1996) (Table 3). Tests for seasonal differences in *R. evertsi evertsi*, the *Rhipicephalus* sp. and *M. winthemi* were not significant at the $P \leq 0,05$ level. *Rhipicephalus evertsi evertsi* occurred in more-or-less equal numbers throughout the year (50,58% in the warm months and 49,42% in the cooler months). Results on seasonal variation for both the *Rhipicephalus* sp. and *M. Winthemi* were not significant due to small sample sizes.

The seasonal occurrence for the three most abundant tick species sampled (*B. decoloratus*, *Hyalomma* spp. and *R. evertsi evertsi*) are graphically presented in Fig. 2 and 3. Data on rainfall and atmospheric temperature are given in Fig. 1. *Boophilus decoloratus* showed minor peaks during November to December 1995 and March 1996 with a major

TABLE 1 Tick diversity, total counts on all cattle ($n = 50$), mean (\pm S.E.) burdens per host for the 12-month period, and relative abundance (%) of tick species sampled

Tick species	Total counts	Mean \pm S.E.	Relative abundance (%)
1 <i>Boophilus decoloratus</i>	213 374	359,22 \pm 23,03	87,260
2 <i>Rhipicephalus evertsi evertsi</i>	16 770	28,23 \pm 1,09	6,860
3 <i>Hyalomma marginatum rufipes</i>	5 914	9,96 \pm 0,73	2,420
4 <i>Otobius megnini</i>	4 536	7,64 \pm 1,21	1,850
5 <i>Rhipicephalus follis</i>	1 861	3,13 \pm 0,52	0,760
6 <i>Rhipicephalus gertrudae</i>	1 331	2,24 \pm 0,35	0,540
7 <i>Rhipicephalus</i> sp.	521	0,88 \pm 0,17	0,210
8 <i>Ixodes rubicundus</i>	196	0,33 \pm 0,59	0,080
9 <i>Hyalomma truncatum</i>	24	0,04 \pm 0,01	0,010
10 <i>Margaropus winthemi</i>	11	0,02 \pm 0,01	0,004
Total sample size	24 4538	411,68 \pm 23,24	100,000

TABLE 2 Distribution of the different tick species sampled over the 12-month period in the five localities. Data are expressed as the total number of each species collected at each locality, followed by the percentage contribution each locality made towards the total count for each species

Tick species	Different localities				
	Botshabelo west	Botshabelo middle	Botshabelo east	Victoria Neck	Motlatla
<i>Boophilus decoloratus</i>	51 848 (24,30)	19 313 (9,05) ¹	26 570 (12,45)	83 416 (39,09) ²	32 227 (15,10)
<i>Rhipicephalus evertsi evertsi</i>	2 739 (16,33)	1 853 (11,05) ¹	3 319 (19,79)	5918 (35,29) ²	2941 (17,54)
<i>Hyalomma m. rufipes</i>	2 446 (41,36) ¹	725 (12,26)	785 (13,27)	590 (9,98)	1368 (23,13) ¹
<i>Otobius megnini</i>	72 (1,59)	120 (2,65)	859 (18,94)	261 (5,75)	3224 (71,08) ¹
<i>Rhipicephalus follis</i>	1 746 (93,82) ¹	39 (2,10)	55 (2,96)	19 (1,02)	2 (0,12)
<i>Rhipicephalus gertrudae</i>	1 158 (87,00) ¹	12 (0,90)	64 (4,81)	23 (1,73)	74 (5,56)
<i>Rhipicephalus sp.</i>	49 (9,40)	13 (2,50) ¹	83 (15,93)	370 (71,01) ²	6 (1,15) ¹
<i>Ixodes rubicundus</i>	12 (6,12)	0	154 (78,57) ¹	28 (14,29)	2 (1,02)
<i>Hyalomma truncatum</i>	9 (37,50)	5 (20,83)	8 (33,33)	2 (8,33)	0
<i>Margaropus winthemi</i>	0	0	0	4 (36,36)	7 (63,64)

¹ & ² Superscript numbers indicate significant differences in tick numbers between the localities ($P < 0,05$)

TABLE 3 Differences in tick burdens during the seasons of the year. Data were divided into either two periods, illustrating the six warmer (September to February) and six cooler (March to August) months, or, for *B. decoloratus*, into four periods, illustrating the spring (September to November), summer (December to February), autumn (March to May) and winter (June to July) seasons of three months each

Tick species	Six warmer months		Six cooler months				P-value		
	Total	%	Total	%					
<i>Boophilus decoloratus</i>	49 493	23,20	163 881	76,80			0,00		
<i>Rhipicephalus e. evertsi</i>	8 482	50,58	8 288	49,42			N.S.		
<i>Hyalomma m. rufipes</i>	5 384	91,04	530	8,96			0,00		
<i>Otobius megnini</i>	3 097	68,28	1 439	31,72			0,00		
<i>Rhipicephalus follis</i>	1 784	95,86	77	4,14			0,00		
<i>R. gertrudae</i>	1 230	92,41	101	7,59			0,00		
<i>Rhipicephalus sp.</i>	352	67,56	169	32,44			N.S.		
<i>Ixodes rubicundus</i>	2	1,02	194	98,98			0,00		
<i>Hyalomma truncatum</i>	19	79,17	5	20,83			0,03		
<i>Margaropus winthemi</i>	2	18,18	9	81,82			N.S.		
	Spring		Summer		Autumn		Winter		
	Total	%	Total	%	Total	%	Total	%	
<i>Boophilus decoloratus</i>	13 482 ¹	6,32	36 011 ²	16,88	82 461 ³	38,65	81 420 ³	38,16	0,00

^{1,2,3} Different numbers indicate significant differences

peak during June 1996 (Fig. 2). The *Hyalomma* spp. displayed a major peak in November 1995 to January 1996, but *R. evertsi evertsi* numbers stayed the same for most months with a rise in April 1996 and a drop in winter (Fig. 3).

DISCUSSION

Diversity, relative abundance and distribution

A total of 10 different tick species were observed on the cattle ($n = 50$) over the 12-month study period. Apart from *M. winthemi* (Theiler 1958), most of these tick species are primarily parasites of wild and domestic ruminants (Howell, Walker & Nevill 1983). The

absence of suitable wild hosts in the five study localities illustrates the dominant role played by cattle, sheep and goats in the population dynamics of these ticks. A dense population of livestock occurred on the communal grazing in the area and off host tick development was expected to be fast due to high summer temperatures and good rains. The success rate of host finding is therefore likely to be high.

Boophilus decoloratus

Boophilus decoloratus, the blue tick, was the most abundant species on the cattle grazing on the commonage, and constituted 87,26% of the total tick burden. This observation is in accordance with the findings of a study conducted in Zimbabwe, where

B. decoloratus, a tick which passes through several generations in a year, was the most commonly-occurring species in over-grazed tribal areas (Norval 1979). In both studies, due to the communal land ownership with overpopulation, unskilled farming methods and overgrazing, the prevalence of multi-host ticks on cattle was low, because the microclimates in which the ticks must survive were generally harsh. Particularly susceptible to harsh microclimatic conditions are three-host ticks, in which up to 88% of the extended life cycle may be spent off the host (Norval 1979). According to Norval (1977), the ticks occurring most commonly in tribal areas are one-host species, e.g. *B. decoloratus*, and two-host species, e.g. *H. marginatum rufipes* and *R. evertsi evertsi*. This was confirmed in the present study. Another limiting factor for two- and three-host ticks in communal areas is the limited numbers of intermediate hosts available, due to the extensive hunting and trapping of birds and mammals as food for hungry people in such overpopulated areas (Norval 1982).

In the present study, alopecia, scaling and crust formation of the skin of the cattle were observed on those parts of the body to which large numbers of *B. decoloratus* ticks were attached, such as the lateral aspects of the neck. In addition, severe infestations have other deleterious effects on the host, such as irritation with subsequent anorexia and loss of body condition and predisposition to bacterial, fungal and parasitic infections (Dipeolu *et al.* 1992). The direct effect of *Boophilus* infestations is proportional to the number of ticks engorging successfully on the animal (Uilenberg 1992), and a loss of 0.6–1.5 g body-mass per engorged *Boophilus microplus* female was recorded during a study in Australia (Sutherst, Maywald, Kerr & Stegeman 1983). The two *Boophilus* species are closely related and the heavy *B. decoloratus* burdens (359,22 ± 23,03) observed in the present study could have resulted in similar reductions in mass. Results obtained in a study in the bushveld of South Africa, however, indicated that reduced weaning masses of calves predominantly infested with *B. decoloratus* can be even higher, as they were in the region of 8.0–9.0 g for each engorged female (Scholtz, Spickett, Lombard & Enslin 1991).

Boophilus decoloratus is also responsible for the transmission of two tick-borne diseases of cattle in the area, namely babesiosis due to *Babesia bigemina* infection and anaplasmosis (Dreyer 1997). Due to their high relative abundance and their ability to transmit infectious diseases, *B. decoloratus* is regarded to be the most important tick species that should be controlled by a specific tick management programme in the Botshabelo-Thaba Nchu region.

The critical annual rainfall level for *B. decoloratus* to survive is 375 mm (Theiler 1969), which is well below that recorded for the Botshabelo-Thaba Nchu area (560 mm). In the present study, significant dif-

ferences in seasonal burdens of this one-host tick occurred, with the highest infestations recorded in February to June. This is in accordance with results obtained in the Eastern Cape Province by Robertson (1981) who recorded that *B. decoloratus* ticks were numerous from February to June but were present in low numbers from July to January. In a study done by Rechav (1982) in the same region, no definite pattern of seasonal occurrence was observed but the lowest numbers on hosts were also recorded in early spring, with peaks in summer and autumn (February to June). The various peaks in adult infestations resulting in population 'waves' indicate the completion of several generations in 1 year (Punyua *et al.* 1991). In the present study the three peaks in November/December, March/April, and June respectively, most probably indicate that the blue tick produced three generations during the year. A similar seasonal periodicity with three generations was observed by Baker & Ducasse (1967) in Natal and MacLeod (1970), and MacLeod, Colbo, Madbouly & Mwanau-mo (1977) in Zambia. In Zimbabwe and the former Northern Transvaal, *B. decoloratus* was found to be present throughout the year without any distinct seasonal peaking in prevalence (Jooste 1966), which indicates a possible overlap between generations.

According to Rechav (1982), temperature is probably the main regulating factor in the seasonal patterns of the blue tick. The slow development of eggs in the field during the cold winter and also the longer pre-oviposition period of females (Robertson 1981; Rechav 1982), possibly resulted in the low numbers of adult ticks in the early spring that were recorded during the present study.

When planning a tick management programme against severe infestations of *B. decoloratus*, an existing situation of endemic stability in the cattle against *B. bigemina* and *Anaplasma marginale* infections must be borne in mind and should not be altered in any way (Dreyer 1997). Thus, although its debilitating effects must be controlled, it should not be eradicated so that a constant challenge to calves by these pathogens is ensured. A strategic approach (Pegram, Hargreaves & Berkvens 1995), with acaricidal applications during the two high prevalence peaks in March and June, respectively, that were recorded in this study, should decrease severe tick burdens and reduce the deleterious effects induced by the ticks themselves. The main calving period in the Botshabelo-Thaba Nchu area is in the spring (September to October) and tick infestations of the new calves occurring during November to December should ensure that they develop resistance to *B. bigemina* and *A. marginale* infections while they are still protected by colostral immunity. Infestation by the blue tick during the spring and early summer should also reinforce the immunity of the rest of the herd against the diseases transmitted by it.

A tactical approach (Pegram *et al.* 1995) could also prove an economical and practical means of control in the area as it would allow farmers to assess the extent of the *B. decoloratus* burdens themselves and treat accordingly. Smaller burdens would then be ignored, allowing a constant challenge, and only when higher burdens are observed by the farmers, such as the peaks in March and June, would the cattle be treated.

Rhipicephalus evertsi evertsi

Rhipicephalus evertsi evertsi, the red-legged tick, one of the most important vectors of *Babesia equi* in horses in South Africa (Howell *et al.* 1983), also transmits *B. bigemina* (De Vos & Jorgensen 1992), *A. marginale* (Potgieter 1979) and *Theileria mutans* (Howell *et al.* 1983) in cattle. Certain adult *R. evertsi evertsi* strains produce a toxin resulting in "spring lamb paralysis" in lambs, kids and calves. Severe ear infestations with the immature stages of this species may result in irritation and secondary bacterial infections of the ear canal (Howell *et al.* 1983). The relatively large *R. evertsi evertsi* burdens recorded in the study, especially at Victoria Neck, were comparable to the results obtained in studies in Zambia (MacLeod 1970), the former northern Transvaal Province (Londt *et al.* 1979; Schröder 1980) and north eastern Free State and Eastern Cape Provinces (Horak, Williams & Van Schalkwyk 1991). Burdens recorded in the present study ranged from 0–210 ticks per host with a mean of $28,23 \pm 1,9$. In the other studies burdens of 30 adults per bovine were regarded as high infestations (MacLeod 1970; Londt *et al.* 1979; Schröder 1980; Horak *et al.* 1991). A few clinical cases of lambs suffering from spring lamb paralysis were observed during the present study in Victoria Neck during September and October 1995, thus even though no direct debilitating effects were observed on the bovine hosts the occurrence of high numbers especially on the small stock, needs to be controlled.

The critical annual rainfall level for *R. evertsi evertsi* to survive is 250 mm.

It can maintain itself in grassy areas with any amount of rainfall above that (Theiler 1950). The presence of this two-host tick species throughout the year, with only small seasonal fluctuations, was also observed by Matson & Norval (1977), Schröder (1980), Horak (1982), Rechav (1982), Punyua *et al.* (1991), and Fivaz & De Waal (1993). In the present study, the small prevalence peak observed from March to May 1996 was similar to the January to May peak on cattle in a study in the former Natal Province (Baker & Ducasse 1967), the April to May peak in a study in the Eastern Cape (Rechav 1982) and the March to May peak in a study on sheep in the Free State (Horak *et al.* 1991). In contrast, the peak in a study in the former northern Transvaal (Londt *et al.* 1979) occurred in November to March, which is earlier in the

warmer season, possibly due to the more moderate winter temperatures experienced there. Although the average life cycle of *R. evertsi evertsi* is completed in 63 d under controlled temperature conditions (Rechav, Knight & Norval 1977), it probably takes longer under the climatic conditions of the central Free State.

The results obtained in the present study indicate that environmental temperature, and specifically that during the winter, was probably the major factor that regulated seasonal activity of the red-legged tick. The absence of clear-cut peaks in its numbers, except for the one in April to May, suggests that there was a possible overlap between generations (Rechav 1982), and the continual presence of adult ticks throughout the year indicates that more than one life cycle can be completed annually, as was considered by Matson & Norval (1977).

A programme for the control of *R. evertsi evertsi* ticks could be incorporated with one for the strategic control of *B. decoloratus*, and it is considered that an acaricidal application in March would be very effective in reducing the numbers of *R. evertsi evertsi* as this is during the period with the largest burdens (February to May). A localized tactical approach, focusing on the specific attachment sites, including the ear canal, would probably be adequate to control infestations throughout the rest of the year. It is considered that an acaricide should be locally applied when burdens of more than 30 adult ticks per bovine are observed.

***Hyalomma* spp.**

The mean *Hyalomma* spp. number per host in the present study was $9,98 \pm 0,74$. The bites of these large ticks with their long mouth parts may cause severe hide damage even if the infestation is low. Secondary bacterial infection at the site of bite wounds commonly result in abscess formation (Fourie & Kok 1995). Depending on their location, such abscesses may have such serious consequences as the loss of teats and udder quarters in cows, or the loss of fertility in breeding bulls (Uilenberg 1992).

Various inguinal abscesses associated with *Hyalomma* bite wounds were observed in several of the animals. *Hyalomma marginatum rufipes* can also transmit *Anaplasma marginale* in bovines (Potgieter 1979). A specific management programme for this tick species is deemed necessary for the areas under review.

Only 0,4% of the *Hyalomma* spp. ticks collected during the study was *H. truncatum*, with the majority (99,6%) being *H. marginatum rufipes*. The small bontpoot tick, *H. truncatum* ranges in its distribution from desert areas to those having up to 500 mm of rainfall per annum (Theiler 1969), thus the average annual rainfall of 560 mm per year in the Botshabelo-Thaba Nchu area might have been a limiting factor on higher numbers. The large bontpoot tick, *H. margi-*

natum rufipes tolerates moister conditions much better and occurs in areas receiving up to 500–625 mm of rain a year (Theiler 1969), which include the area of this study.

Summer burdens of *H. marginatum rufipes* and *H. truncatum* were significantly higher compared with winter burdens, resembling the results obtained in studies done in the former northern Transvaal (Londt *et al.* 1979; Horak 1982) and western Transvaal Province (Rechav 1986), Zimbabwe (Matson & Norval 1977) and south-western Free State (Fourie, Kok & Heyne 1996). The long summer peak (October to February) in the present study possibly indicates the overlapping of more than one generation. All localities displayed a summer peak, but significantly higher numbers were seen in Botshabelo-west (41,36%) and Motlatla (23,13%). In both Botshabelo-west and Motlatla cattle graze on large open grassveld areas, and it is possible that the habitat in these two regions was more favourable for intermediate hosts than the three other areas. The fact that low numbers (12,26%) of *H. marginatum rufipes* were seen in Botshabelo-middle emphasizes this phenomenon, because the cattle there were only allowed to graze on the large open areas within the city boundaries where no or few intermediate hosts would be found.

A tactical approach of control of these *Hyalomma* spp. with local acaricidal applications during the long October to February peak would be practical and feasible for the Botshabelo-Thaba Nchu areas. It is considered that when farmers observe burdens of more than 15 *Hyalomma* spp. ticks in the perineal and inguinal areas of their cattle, the infestations should be treated with a local application of e.g. tick-grease.

Otobius megnini

Heavy infestations of *O. megnini* may result in trauma and secondary infections of the pinnae, ear canals and auditory nerves of cattle, resulting in anorexia, loss in condition, ataxia and, ultimately, the death of the host. *Otobius megnini* also parasitizes sheep, goats, horses, donkeys, dogs, cats and even people and may induce similar clinical signs and lesions (Howell *et al.* 1983). In the Botshabelo and Thaba Nchu areas, livestock and companion animals are kept in close association with one another in the backyards of cattle owners and it is possible that host species other than cattle become infested. The second nymphal stage of *O. megnini* drops off after engorgement in the kraals, yards and sheds where livestock are housed, and needs the protection of cracks and grooves such as those found in a wooden or stone enclosure to develop into adults (Howell *et al.* 1983). The results indicate that *O. megnini* infestations in Motlatla, where 71,08% of the total sample were recorded, were much higher than those in the other localities. In Motlatla most of the kraals in the backyards were of wooden or stone enclosures, in

contrast to the wire fencing of kraals in the other localities. In Botshabelo-east with the second highest abundance of *O. megnini* (18,94%), one of the participating farmers also used a stone enclosure.

Otobius megnini burdens showed no specific seasonal periodicity, in accordance to observations made by Theiler & Salisbury (1958). It is felt that a localized control approach of the ear canal, in concurrence with treatments against *R. evertsi evertsi* immatures, would be sufficient to control this tick species.

Rhipicephalus gertrudae and *Rhipicephalus follis*

Although the numbers of *R. gertrudae* and *R. follis* were much lower than the above-mentioned species, it is felt that they must have contributed to the tick-worry situation which the cattle were subjected to, by causing open wounds at their attachment sites (Dreyer 1997). Eighty-seven percent and 93,82%, respectively, of *R. gertrudae* and *R. follis* ticks collected were from the Botshabelo-west area. According to Walker (1991), *R. gertrudae* occurs widely in the former Cape Province, and its distribution extends northwards into Namibia and eastwards into the southern and central Free State Province. The smaller numbers of *R. gertrudae* adults recovered in the present study in the eastern, higher areas (Motlatla, Victoria Neck), with their prevalence increasing in a westerly direction to Botshabelo-west, confirms the statement by Horak & Fourie (1992) that their numbers increase from east to west in the Free State. Cattle are the most frequently-recorded domestic animal hosts of *R. follis* (Walker 1991), although it never occurs in large numbers on any animal species with the exception of the eland (*Taurotragus oryx*) (Horak & Fourie 1992).

Adults of *R. gertrudae* and *R. follis* are typically active in summer and in the present survey most ticks were collected during the six warmer months. Apparently these two species, as well as the *Rhipicephalus* n. sp. displayed a seasonally-regulated life cycle and passed through only one generation during the 12 month period. The minimum duration of a tick's life cycle increases from one- to three-host ticks, as a result of the increased proportion of the life cycle spent off the host (the non-parasitic phase) (Matson & Norval 1977). In this study these ticks were active from September to February. On cattle in the south-western Free State, *R. gertrudae* adults were present during summer, with peaks in September and January (Fourie *et al.* 1996). On gemsbok (*Oryx gazella*) in a nature reserve in the Free State, small numbers of *R. gertrudae* and *R. follis* burdens were present from September to December (Fourie, Vrahimis, Horak, Terblanche & Kok 1991). Horak, Keep, Spickett & Boomker (1989) recovered adult *R. follis* from bushbuck (*Tragelaphus scriptus*) in the Weza State

Forest in the former Natal Province, from December to April, and in a study in the Mountain Zebra Park *R. follis* was recovered from eland (*Taurotragus oryx*) during November and December (Horak, Fourie, Novellie & Williams 1991). In all cases, including the present study, both *R. gertrudae* and *R. follis* were observed only during the summer months.

***Rhipicephalus* sp.**

This tick was previously sampled in the south-western Free State and referred to as *R. punctatus* (Horak & Fourie 1992). The most recent studies, however, indicate that the tick occurring in the Free State is a new species in the *Rhipicephalus pravus* group and it will be described shortly (Jane B. Walker & I.G. Horak, personal communication 1998). It is commonly known as the brown paralysis tick because in some areas it causes paralysis in sheep and goats (Fourie & Kok 1992) but a certain infestation density is required to induce this condition. The relative abundance (0,21%) of this *Rhipicephalus* sp. was low in this study, but its occurrence does pose a potential threat to small stock as far as the paralysis syndrome is concerned. The most important host for its immature stages is the rock elephant shrew, *Elephantulus myurus* (Fourie, Horak & Marais 1988). The natural habitat of this rock elephant shrew is rocky outcrops with an abundance of cracks and crevices to provide shelter (Du Toit 1993), and it is thus reasonable to assume that the adult ticks will also be more abundant in areas with rocky outcrops and hills (Fourie & Horak 1990). Results in the present study confirmed this assumption in that the highest numbers of this *Rhipicephalus* sp. (7,01%) were collected at Victoria Neck, where cattle are allowed to graze on the hilly areas of the two koppies situated next to the village. The lowest numbers were recorded at Motlatla (1,15%) which has large, open grassveld areas and an absence of rocky outcrops, and Botshabelo-middle (2,50%) where cattle graze on the open areas within the city and the environment is unfavorable for the intermediate hosts.

It was determined in this investigation that the *Rhipicephalus* sp. was also only active during the warmer months. This is in accordance with findings of a study of its prevalence on cattle in the south-western Free State (Fourie *et al.* 1996). In another study on cattle on a commercial farm in the Free State Province, this species was present during January and April, and from September to November (Fourie & Horak 1990).

Ixodes rubicundus

The relative abundance (0,08%) of *I. rubicundus*, the Karoo paralysis tick, on the cattle in the present study was very small, with a mean infestation rate of 0,33 ($\pm 0,59$) ticks per host and a maximum infestation of 14 ticks per host. The reason for the low numbers recorded on the cattle could be that the preferred

domesticated host for adults of this species is the sheep (Fourie & Horak 1991).

Furthermore, most of the Botshabelo-Thaba Nchu area, with the exception of the Botshabelo-east area is grassveld and not typical karroid vegetation, the habitat most suitable for the increase of this species. The largest collection of *I. rubicundus* (78,57%) was made at Botshabelo-east where most of the herds graze on the communal ground on the southern side of a koppie with Karoo-veld vegetation. *Ixodes rubicundus* is found in a Karoo or False-Karoo habitat, in association with specific Karoo plants, including either the bush *Rhus erosa* (besembos) or the grass *Merxmüllera disticha* (mountain wire grass) (Theiler 1969; Spickett & Heyne 1988).

Ixodes rubicundus causes an often fatal syndrome in hosts, characterized by paresis and paralysis by producing a toxin which is present in its saliva (Fourie, Petney, Horak & De Jager 1989). Information obtained from a questionnaire survey carried out in South Africa, revealed that 115 400 small stock died as a result of this syndrome during 1983–1987 (Spickett & Heyne 1988). Paralysis in cattle also occurs and is often observed (Spickett & Heyne 1988; Fourie unpublished data 1998). A certain number of attached adult ticks per kg of host body mass is required before the clinical signs of paresis and paralysis are induced. In a study performed on sheep a minimum of 0,32 ticks/kg host body mass induced the paralytic syndrome (Fourie *et al.* 1989). The maximum number of 14 *I. rubicundus* ticks collected from one individual animal in the present study would therefore probably have been too small to have caused paralysis or paresis but, as the ticks do occur in the area, they do pose a potential threat to the livestock in this respect.

Ixodes rubicundus is a three-host tick whose adults are active from April to September, with peak burdens on hosts recorded during either April (Horak & Fourie 1992) or May to June (Fourie *et al.* 1989; Fourie, Horak & Van Zyl 1992; Horak & Fourie 1992; Fourie *et al.* 1996). The present study confirmed these results, with 98,98% of the these ticks being collected from March 1996 to August 1996, with a peak in their numbers in June. Available information suggests that the tick is usually active until September or October in the summer rainfall areas of this country, while in the winter rainfall areas, it is active until November or December (Stampa 1959; Fourie *et al.* 1989; Fourie & Horak 1991). It is possible that rainfall enhances its ecological lifespan but it is possible that adults are able to remain active for only one season (Horak & Fourie 1992).

Margaropus winthemi

Victoria Neck and Motlatla, the two Thaba Nchu villages, are situated nearer to the Thaba Nchu mountain and are located at a higher altitude and receive

more frost and rain than the Botshabelo area does. The latter is located on a plain to the west of Thaba Nchu. *Margaropus winthemi*, the winter horse tick, is a one-host and essentially a winter tick most commonly found on horses (Howell *et al.* 1983).

During the study period a few of these parasites were collected from the cattle only from April to September. The absence of ticks from October to March suggests that overwintering must occur either as detached engorged females or, more probably, as eggs (Horak *et al.* 1991). High atmospheric temperature is the limiting factor to the distribution of this tick (Theiler 1958; Gothe 1967; Howell *et al.* 1983) and the small differences in altitude and climate could possibly explain why *M. winthemi* was only found in the Thaba Nchu area and not in Botshabelo. Another factor which could have influenced its distribution is that large numbers of horses graze with the cattle herds in the Thaba Nchu area, and therefore probably served as a source of infestation. In Botshabelo, however, due to the crime problem, horses are kept tethered near the houses (Dreyer 1997). The presence of *M. winthemi* infestations, even in small numbers, has a debilitating effect on their hosts, especially because they occur in winter when many animals are stressed due to the cold and poor nutritional value of the grazing (Howell *et al.* 1983).

Before any economical tick control plan is developed for a region or farming system, it is considered necessary to quantify the livestock production losses associated with different degrees of tick infestation. In the present study no attempts were made to determine economical losses caused by the ticks. It is, however, very difficult to evaluate such losses, and much depends on the type of production system in which the animals are maintained. In areas where livestock are not primarily kept for beef production but rather as part of a traditional agropastoral farming system, such as in the area under review, where the primary output is milk, a valuation of potential production losses is an even greater problem (Norval, Barrett, Perry & Mukhebi 1992). Nevertheless, the results obtained in this study do provide valuable information needed for the formulation of tick control strategies in the Botshabelo and Thaba Nchu areas.

A strategic approach consisting of two acaricidal applications in March and June, focusing on ventral body parts against *B. decoloratus* burdens, and a tactical approach, focusing on the perineal and inguinal areas of the animals during warmer months against *Hyalomma* spp. and *R. evertsi evertsi* could well offer a suitable and economically sustainable means of tick control for small farmers in the area under review. The benefit of this approach, however, would be enhanced by implementing it with an integrated tick control programme incorporating the use of biological control methods, possible selection of breeding stock and, ultimately, if methods are ever developed, immunization against ticks.

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