



Survey of the livestock ticks of the North West province, South Africa

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Ticks, as vectors of disease and damage agents, impact directly and indirectly on the economy of the livestock industry in southern Africa. This study surveyed the occurrence and distribution of ticks infesting livestock across the North West province, South Africa. During three phases in consecutive years, officers of the provincial Veterinary Department collected specimens monthly from livestock hosts at specified sites across the province. Data analysis constituted the fourth phase of the study. A total of 1090 collections from 265 sites yielded 42 566 tick specimens, comprising 22 different tick species (18 ixodids, 4 argasids). The specimens represent all of the major tick vectors of disease that occur in South Africa. The major tick-borne diseases (i.e. heartwater, both African and Asiatic bovine babesiosis and anaplasmosis) were found to be prevalent mainly in the north-eastern region of the province, which also displayed the highest tick species diversity. The central region appears transitory to some of the major vectors. Although some tick species were contained within specific regions, others were widespread across the province. Associated serology data show that most herds sampled in areas endemic for babesiosis and anaplasmosis in the north-eastern region are endemically unstable and at risk to these tick-borne diseases should vector control measures become ineffective.

Introduction

Ixodid ticks are economically of the most important external parasites of livestock in the tropical and sub-tropical parts of the world, including South Africa. Heavy infestation can cause loss of blood, reduce live weight gain rates and lower milk yield, whilst the long-mouthed ticks downgrade the quality of the hides and cause secondary infections (De Castro 1997). They are also recognised worldwide as major vectors of a number of disease-causing pathogens in humans and domestic and game animals, including arboviruses, rickettsiae, spirochaetes and parasitic protozoa. They act as reservoirs and/or multipliers of these organisms and transmit a number of important tick-borne diseases such as heartwater, bovine babesiosis, anaplasmosis and theileriosis. Some ixodid ticks also produce toxins that cause paralysis in sheep (Spickett & Heyne 1988) and sweating sickness in calves (Jongejan & Uilenberg 1994).

Ticks therefore impact both directly (by virtue of heavy infestations) and indirectly (through the transmission of tick-borne diseases) at an economical level as well as in a social context. At the macro-economic level, exports and the commercial production of protein may be affected and at the micro-economic level the subsistence economy of the resource-poor farmer may be at risk. Whilst little actual data exist, it was estimated already some 30 years ago that mortality losses attributed to tick-borne diseases, together with acaricide and vaccine costs, were in the region of R70 million per annum (Van Rensburg 1981), whilst a panel of the Food and Agriculture Organization placed total losses in South Africa at R550 million per annum in 1985. However, these are estimates at best and many resources would have to be harnessed in order to determine more accurate figures regarding the economic impact of ticks. Only one study – on heartwater, which is probably the most important tick-borne disease in South Africa – has been attempted (Minjauw 2005), with total annual losses estimated at R189.6 million.

Paramount to assessing the impact of vectors and disease agents are the identification of the species involved, their distribution and their association with disease. Long-term research since the time of Arnold Theiler in the early 20th century, including the last comprehensive tick survey in South Africa by Gertrud Theiler in 1957 (Theiler 1962), has placed South Africa in the fortunate position of having a wide knowledge of ticks and their associated disease epidemiologies. These findings are documented in wide-ranging publications, with the most important disease-oriented knowledge being condensed into two publications (Coetzer & Tustin 2004; Walker, Keirans & Horak 2000). In the South African context, some 90 ixodid and 25 argasid tick species have been identified. Of these, 35 are normally associated with domestic animals and approximately 15 are considered of economic importance. They transmit, or are associated with, some 23 diseases or health syndromes (Norval & Horak 2004).

In the context of ticks and tick-borne diseases affecting livestock resources, the Directorate of Veterinary Services in the North West province (Department of Agriculture), commissioned a survey to determine tick species presence, their seasonal occurrence, contribution to livestock diseases and distribution across the province.

Materials and methods

Study locality

The survey was conducted over a total area of 116 320 km² in the North West province of South Africa (between approximately 24°15'S, 22°30'E and 28°15'S, 28°30'E). The area may, according to Acocks (1988), be sectorised roughly into three main regions based on vegetation (Figure 1). The north-eastern region consists of bushveld (Mixed, Sour and Sourish-mixed Bushveld, the latter interspersed with Bankenveld and Turf Thornveld). The central region has an equally mixed vegetation, consisting of Dry and Sandy *Cymbopogon*-*Themeda* veld with Sourish-mixed Bushveld in its northern reaches. The western, more arid region of the province consists mainly of Kalahari Thornveld.

The climate of the province is characterised by well-defined seasons: hot summers and cool, sunny winters. The climate and rainfall vary from the more mountainous and wetter eastern region to the drier, semi-desert plains of the Kalahari in the west. The rainy season usually falls between October

and March. Rainfall is highly variable, with regard to both time and region. On average, the western part of the province receives less than 300 mm rainfall per annum, the central part around 550 mm and the eastern and south-eastern parts receive more than 600 mm.

There are wide seasonal and daily variations in temperature. Summers are very hot (daily average maximum temperatures of 32 °C in January) and winters are mild to cold (average daily minimum in July is 1 °C). The far western part is arid, encompassing the eastern portion of the Kalahari Desert. The central part of the province is typically semi-arid, whilst the eastern region is predominantly temperate.

Agriculture is the second most important economic activity. The eastern, wetter region of the province largely supports livestock and crop farming, whilst the central and southern regions are dominated by wheat and maize farming. Livestock and game farming occur in the semi-arid western region of the province. Tourism is considered to have a major growth potential as the province has a rich natural heritage and a network of well-managed, malaria-free national and provincial parks and nature reserves, which boast the 'Big Five'. According to the Department of Agriculture, Forestry and Fisheries (2004) livestock production revolves around the estimated 1.77 million cattle, 729 000 sheep and 753 000 goats in the province. Approximately 43% of cattle, 46% of sheep and 47% of goats are owned by the communal sector. The

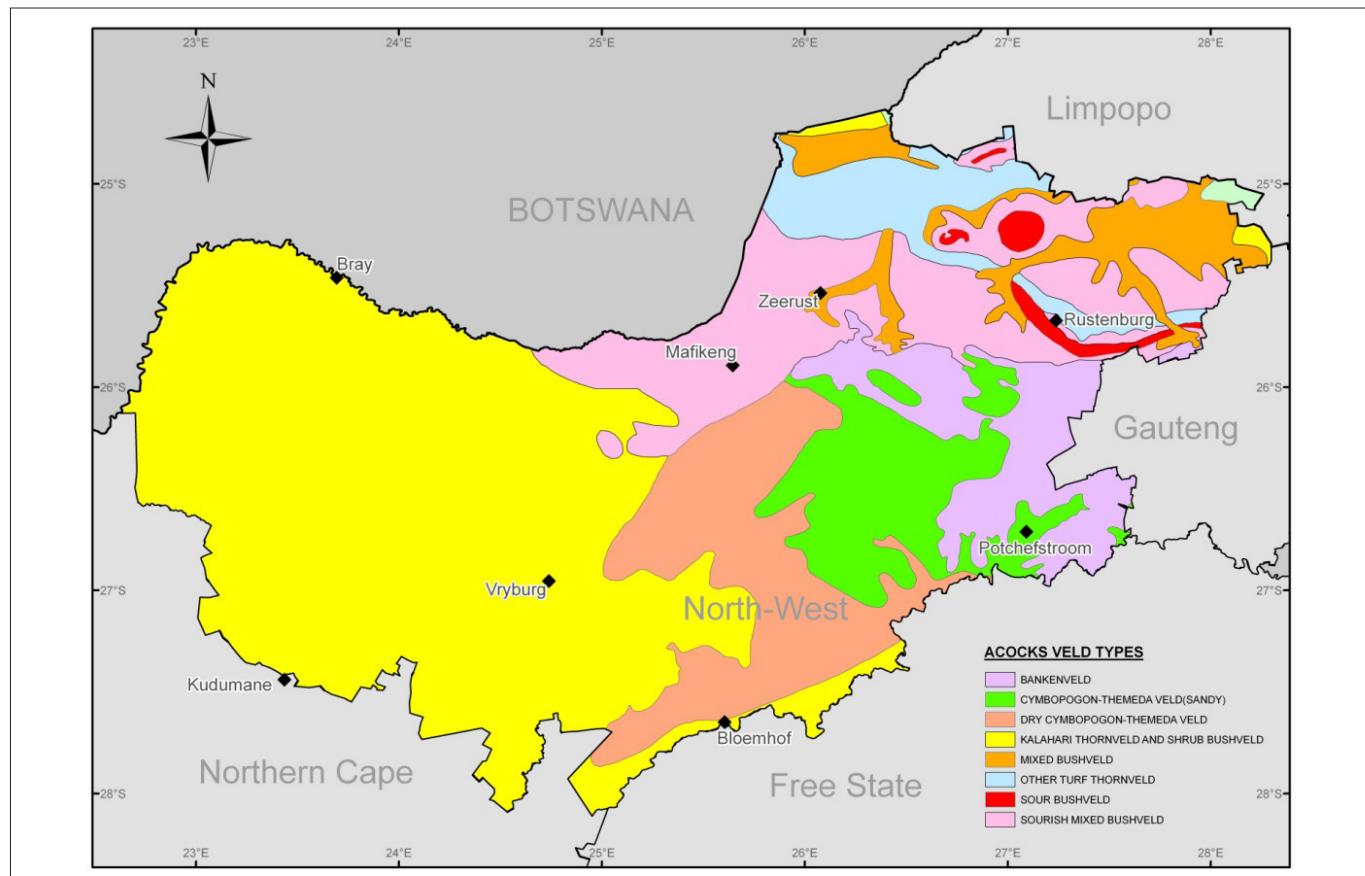


FIGURE 1: Vegetation types of the North West province of South Africa, according to Acocks, J.P.H., 1988, *Veld types of South Africa with accompanying veld type map*, 3rd edn., Department of Agriculture and Water Supply, Pretoria.

majority of cattle are found in the north-eastern region (42%), with 34% and 24% being in the central and western regions, respectively. Sheep and goats are farmed predominantly in the western region (44% and 46%, respectively), whilst only to a limited extent in the north-eastern and central regions (sheep: 29% and 27%, respectively; goats: 34% and 20%, respectively). It is this considerable livestock resource that could be adversely affected by ticks and tick-borne diseases.

Survey design and execution

The survey was conducted in four phases over a number of years since 2001. The first three phases included monthly tick collections from identified sites in the north-eastern, central and western regions during three consecutive years (Figure 2).

Collection sites were selected from 1:250 000 charts and subsequently between four and 41 collection sites, depending on spatial distribution, logistics and collectors' time constraints, were assigned to specific areas in each of the three regions (Table 1). Areas considered marginal for specific tick species were included in the selected sites. A total of 114 sites were selected in the north-eastern region (collection phase 1), 116 in the central region (collection phase 2) and 61 in the western region (collection phase 3). As comprehensive coverage as possible of the province was sought to allow for tick distribution mapping. Collection sites were not assigned to the immediate north-east and north-west of Bloemhof (central region) owing to crop farming predominating in these areas.

During each collection phase, nominated animal health technicians from each region received in-house training in basic tick identification, collection and specimen handling before collection commenced at their specified sites. The fourth phase (performed at the Onderstepoort Veterinary Institute [OVI]) involved species identification, database acquisition, distribution mapping using ArcGIS (ESRI) software and reporting.

Ticks were collected off one side of livestock hosts – mainly cattle, goats and sheep – using forceps. Each collection was placed in 70% alcohol in a specimen bottle for dispatch to the OVI for identification and recording. Only one collector, in the Bray area, consistently sampled chicken coops. Owing to prior training collectors were able to perform basic tick species identification *in situ*, so that as wide a range of species present on the animal could be collected. To gain data on species seasonality, monthly collections from most sites were attempted. Tick collections were, however, disrupted to some extent during the second phase (central region) because of a swine fever outbreak in the Eastern Cape, which required secondment of personnel to assist with containment operations.

In some areas of the north-eastern region, a high incidence of both *Rhipicephalus (Boophilus) decoloratus* and *Rhipicephalus (Boophilus) microplus*, the vectors of bovine babesiosis, was evident. A standard immunofluorescent antibody test (Joyner *et al.* 1972) and a competitive inhibition enzyme-linked immunosorbent assay (Ndung'u *et al.* 1995; Visser *et*

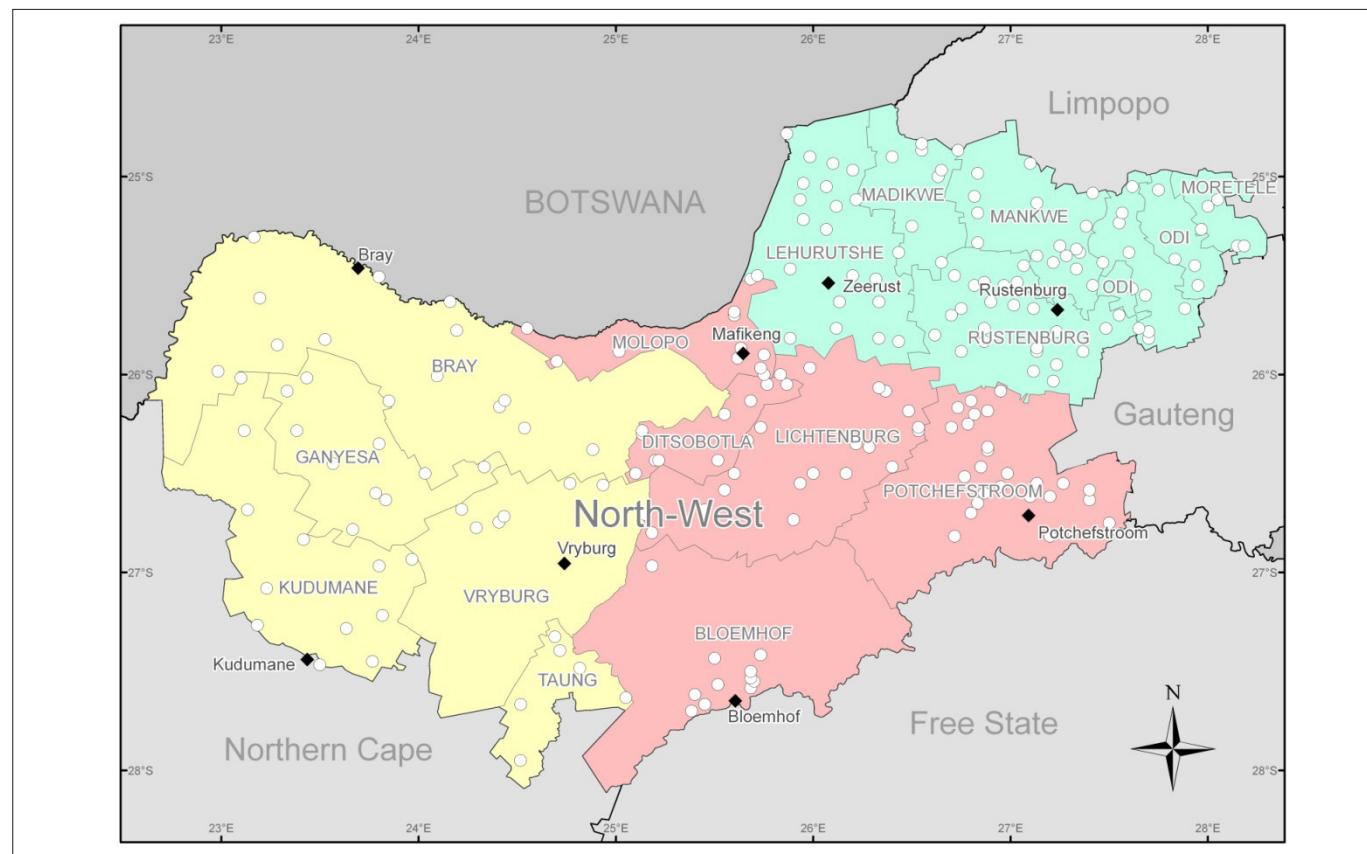


FIGURE 2: State veterinarian areas in the north-eastern, central and western regions that served as collection sites for the three-phase tick collection survey in the North-West province, South Africa.



TABLE 1: Sampling areas in three regions of the North West province, South Africa.

Region	Sampling area
North-eastern region	Lehurutse
	Madikwe
	Mogwase
	Moretele
	Odi
	Rustenburg
Central region	Bloemhof
	Christiana
	Coligny
	Delareyville
	Ditsobotla
	Lichtenburg
	Molopo
	Potchefstroom
	Ventersdorp
Western region	Wolmaransstad
	Ganyesa
	Kudumane
	Taung
	Vryburg1 (Bray)
	Vryburg2

al. 1992) were used to test blood samples for antibodies to *Babesia bovis* and *Babesia bigemina*, and *Anaplasma marginale*, respectively. Sera collected from 13 properties in the affected areas (from at least 30 cattle per herd, 9–12 months of age) were tested to determine the antibody status of these herds to African and Asiatic babesiosis and anaplasmosis.

Results and discussion

Number of ticks, species composition and collections

A total of 42 566 ticks (from 1190 collections across 265 collection sites) were received for identification. The breakdown of collections is as follows:

- (1) north-eastern region: 21 045 specimens from 429 collections
- (2) central region: 10 391 specimens from 398 collections
- (3) western region: 11 130 from 363 collections.

Owing to the collection method employed almost all the ticks received were adults (97.9%), with roughly equal numbers of males and females. The immatures (nymphs = 1.8%; larvae = 0.3%), mostly *Rhipicephalus evertsi evertsi* and four nymphs of *Otobius megnini*, were collected more by chance than intention from the ears of cattle.

Altogether 22 tick species were identified (18 from six Ixodidae genera; four from three Argasidae genera). The main tick species were all hard ticks (Ixodidae) and included *R. evertsi evertsi* (31.5%), *Hyalomma rufipes* (22.4%), *Amblyomma hebraeum* (17.3%), *R. (B.) decoloratus* (12.5%), *Rhipicephalus appendiculatus* (11.2%), *Hyalomma truncatum* (2.3%), *R. (B.) microplus* (1.6%), *Rhipicephalus evertsi mimeticus* (0.5%) and *Rhipicephalus simus* (0.21%). Other ticks of lesser importance or those collected in low numbers or during only a few collections, as well as the Argasidae collections, are as shown in Table 2.

Monthly collections over a period of 10–12 months were received from 70 collection sites, which allowed the seasonal occurrence of the major tick vectors to be determined. Monthly collections from a further 175 collection sites were received over a period varying from 1 to 9 months.

Tick species distribution and seasonality

The distribution patterns and seasonality of the major tick species collected are described below.

Amblyomma hebraeum

According to Norval and Horak (2004), *Amblyomma hebraeum* is present in grassed bushveld and wooded savanna regions. In the present survey, *A. hebraeum* accounted for 17.3% of the collected ticks and appears well established in the Mixed and Sourish-mixed Bushveld areas of the North West province (Figure 3). It is present mainly in the north-eastern and northern portion (Mixed Bushveld) of the central region, with singular intrusions into the Kalahari Thornveld south-east of Vryburg and west of Mafikeng. The latter distribution appears to be established populations because they were consistently collected during the summer months at these sites.

Adult ticks prefer large hosts such as cattle and large wild ruminants, but also infest sheep and goats (Horak *et al.* 1987; Walker *et al.* 2003). In this survey 90.8% of *A. hebraeum* specimens were recovered from cattle, 4.9% from goats and 3.3% from sheep (1.0% were not stipulated). The adults of this species were present throughout the year, with a high incidence in both the north-eastern and central regions during November and December (summer), similar to observations by Rechav (1982) for the Eastern Cape. Higher numbers of adults were found in the central region between March and May (autumn) than in the north-eastern region during these months.

Hyalomma rufipes

H. rufipes (previously the subspecies *Hyalomma marginatum rufipes* [Apanaskevich & Horak 2008]) is a vector of the Crimean–Congo haemorrhagic fever virus. It is the most widely distributed species of this tick genus in South Africa, occurring in the greater part of the country (Norval & Horak 2004). It was found distributed widely over the whole of the North West province, with it being absent from only eight of the collection sites (Figure 4). The life cycle may be completed in one year and peak numbers of adults were evident in the summer months (November–February).

H. rufipes accounted for 22.4% of the total number of specimens collected in this survey. Of these, 97.2% were from cattle, 1.5% from sheep and 0.5% were found on goats (0.8% were not assigned a host).

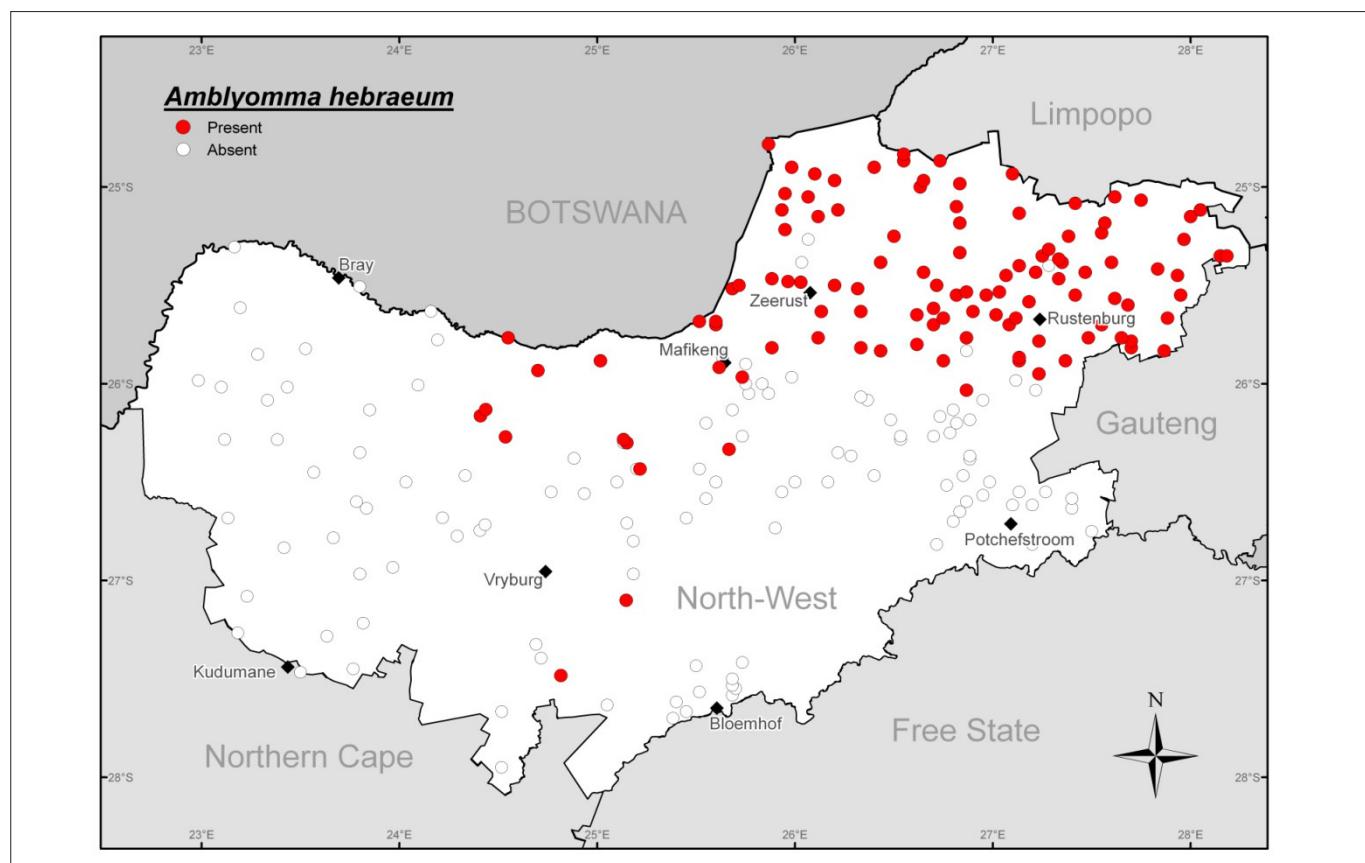
Hyalomma truncatum

H. truncatum is widely distributed over the whole of the North West province (Figure 5) and was present in all the ecological zones sampled. Of the adult *H. truncatum* specimens collected, 89.9% were from cattle, 0.8% from sheep and 8.5% from

TABLE 2: Ixodid ticks of lesser importance and argasid ticks identified from each of the three collection regions.

Regions	Ixodid ticks			Argasidae ticks		
	Species	Specimens†	Collections‡	Species	Specimens†	Collections‡
North-eastern	<i>Haemaphysalis elliptica</i>	14	3	-	-	-
	<i>Ixodes pilosus</i> group	2	2	-	-	-
	<i>I. rubicundus</i>	7	6	-	-	-
	<i>Rhipicephalus follis</i>	1	1	-	-	-
	<i>R. gertrudae</i>	2	2	-	-	-
	<i>R. near pravus</i>	29	18	-	-	-
	<i>R. sulcatus</i>	14	6	-	-	-
	<i>R. zambeziensis</i>	5	5	-	-	-
Central	<i>H. elliptica</i>	12	5	<i>Otobius megnini</i>	4	4
	<i>R. follis</i>	58	14	-	-	-
	<i>R. near pravus</i>	2	2	-	-	-
Western	<i>H. elliptica</i>	3	3	<i>Argas persicus</i>	406	9
	<i>Margaropus winthemi</i>	56	9	<i>A. walkerae</i>	2	1
	<i>R. near pravus</i>	3	2	<i>Ornithodoros savignyi</i>	54	3
	<i>R. sulcatus</i>	6	2	-	-	-

†, The number of specimens collected; ‡, the number of collections from which these specimens were collected.

**FIGURE 3:** The geographic distribution of *Amblyomma hebraeum* in the North West province, South Africa.

goats; 0.8% were not assigned a host. *H. truncatum* accounted for only 2.3% of the total number of specimens collected. Some strains of this species transmit a toxin that causes an epitheliotrophic condition called sweating sickness, which affects young calves in particular (Neitz 1959). The tendency for adults to attach preferentially in the tail switch of cattle (where it is easily overlooked during sampling) may explain why this tick was not collected at more of the collection sites. Its seasonal occurrence in the North West province confirms its annual life cycle, with adults reaching peak numbers between January and March.

Rhipicephalus appendiculatus

R. appendiculatus is restricted to the higher-rainfall, eastern regions of South Africa (Walker *et al.* 2000) and according to Theiler (1962) does not occur in open grassland without bush; it prefers tall grass interspersed with trees. Accordingly, this species was found well established in the north-eastern region of the province and in the bushveld areas of the northern reaches of the central region around Mafikeng (Figure 6). The remainder of the province, especially the western region, appears to be ecologically unsuited to the establishment of this tick species.

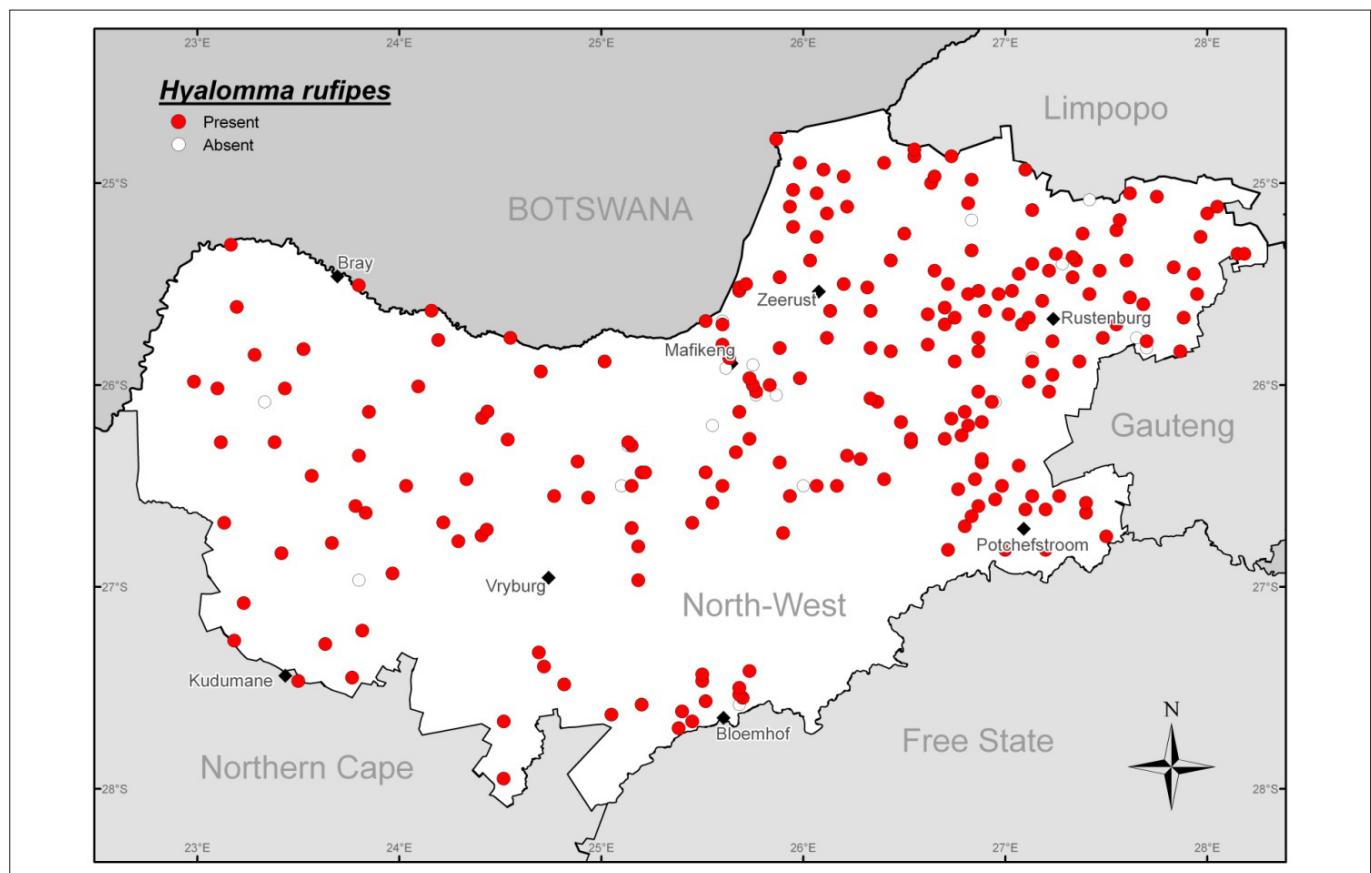


FIGURE 4: The geographic distribution of *Hyalomma rufipes* in the North West province, South Africa.

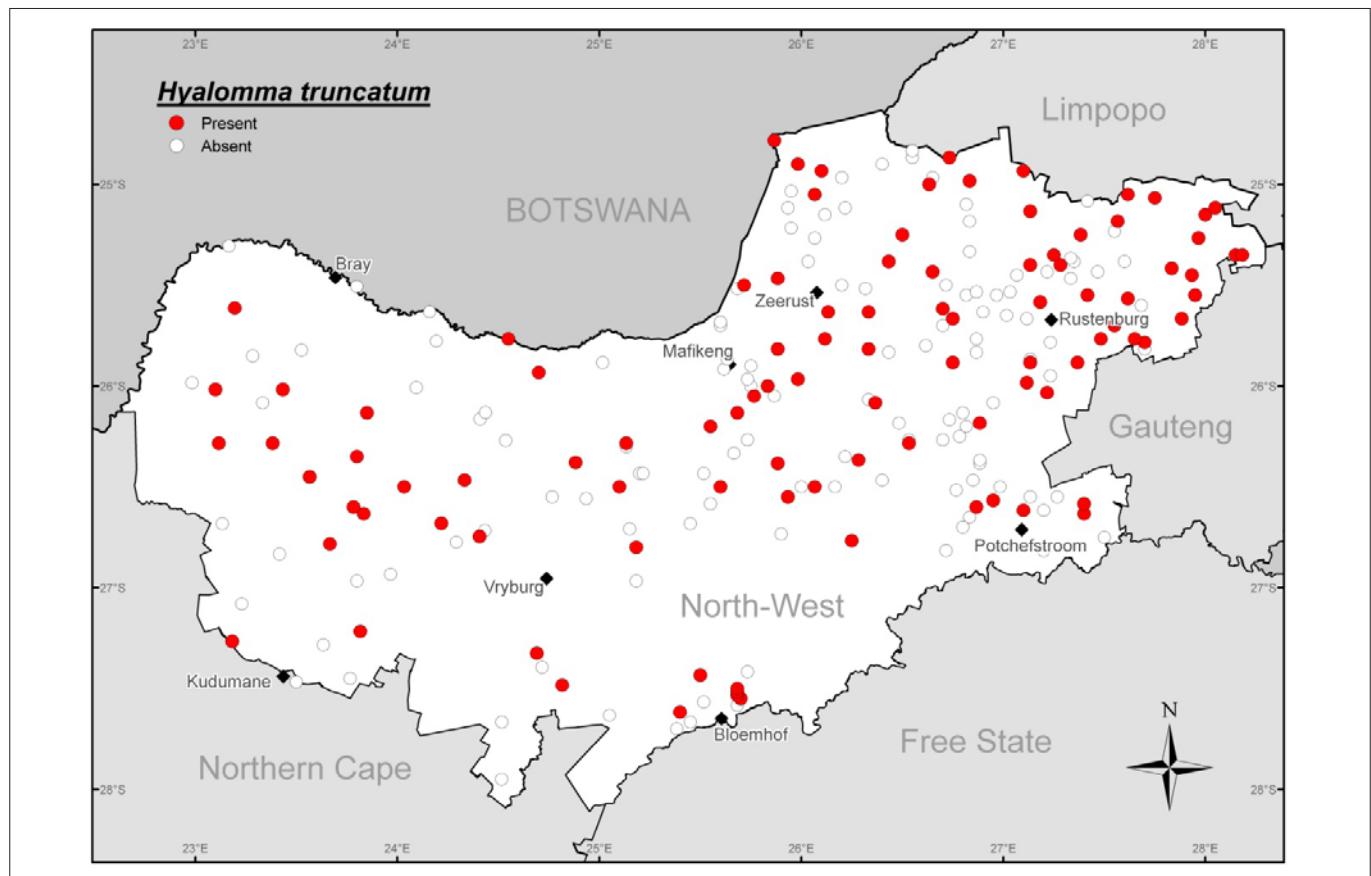


FIGURE 5: The geographic distribution of *Hyalomma truncatum* in the North West province, South Africa.

This species accounted for 11.2% of the specimens collected. Of the total number of adults collected, 86.9% were from cattle, 7.4% from goats and 5.0% from sheep; the remaining 0.7% were not assigned a host. Adult activity commenced only during the summer months (between December and March), as reported for the Eastern Cape by Rechav (1982).

Rhipicephalus (Boophilus) decoloratus

The ticks we have chosen to name *R. (B.) decoloratus* and *R. (B.) microplus* were originally known as *Boophilus decoloratus* and *Boophilus microplus*, respectively. However, based on molecular evidence (Beati & Keirans 2001; Murrell, Campbell & Barker 2000), they were included in a 2002 world list of valid tick names as *R. (B.) decoloratus* and *R. (B.) microplus* (Horak, Camicas & Keirans 2002). Guglielmone *et al.* (2010) have subsequently omitted the subgenus and these ticks appear in their list of valid tick names as *R. decoloratus* and *R. microplus*. We chose to include the subgenus in our nomenclature.

R. (B.) decoloratus represented 12.5% of the collections in this survey, with 98.1% of specimens being collected from cattle, only 0.5% from sheep and 0.3% from goats. The remaining 1.1% were not assigned hosts. This distribution confirms its host preference for large ungulates (Mason & Norval 1980). The species normally occurs in temperate savanna regions, typically in grass- and woodland areas used by cattle, and tends to be absent in drier areas (Walker *et al.* 2003). It is well established in the grassed Bushveld biomes (especially

the Sourish-mixed Bushveld) of the north-eastern region and northern reaches of the central region of the North West province, around Rustenburg, Zeerust, Mafikeng and Potchefstroom (Figure 7). The tick also inhabits seemingly suitable habitats (probably created by irrigated land use) in the *Cymbopogon*-*Themeda* veld near Bloemhof and the Kalahari Thornveld near Kudumane and Vryburg in the western region. Apparently, suitably high temperatures – well above the developmental threshold of 10 °C (Spickett & Heyne 1990) – and host availability yielded high numbers of this one-host species, even during the winter months. Peak numbers were evident in December and January and again from March to July. Since *R. (B.) decoloratus* is a vector of *B. bigemina*, African babesiosis may therefore be a threat throughout the year.

Rhipicephalus (Boophilus) microplus

R. (B.) microplus, as *R. (B.) decoloratus*, inhabits savanna climatic regions in wooded grasslands used as cattle pasture (Walker *et al.* 2003). *R. (B.) microplus* (Figure 8) was found to have a more limited distribution compared to that of *R. (B.) decoloratus*, being confined to the Sourish-mixed Bushveld of the north-eastern region (around Rustenburg, north-east of Potchefstroom and north of Zeerust). The species was also found in an isolated pocket near Bloemhof, probably introduced by cattle and finding suitable habitats here.

Cattle are considered the only effective hosts of *R. (B.) microplus* (Mason & Norval 1980), to the extent that this

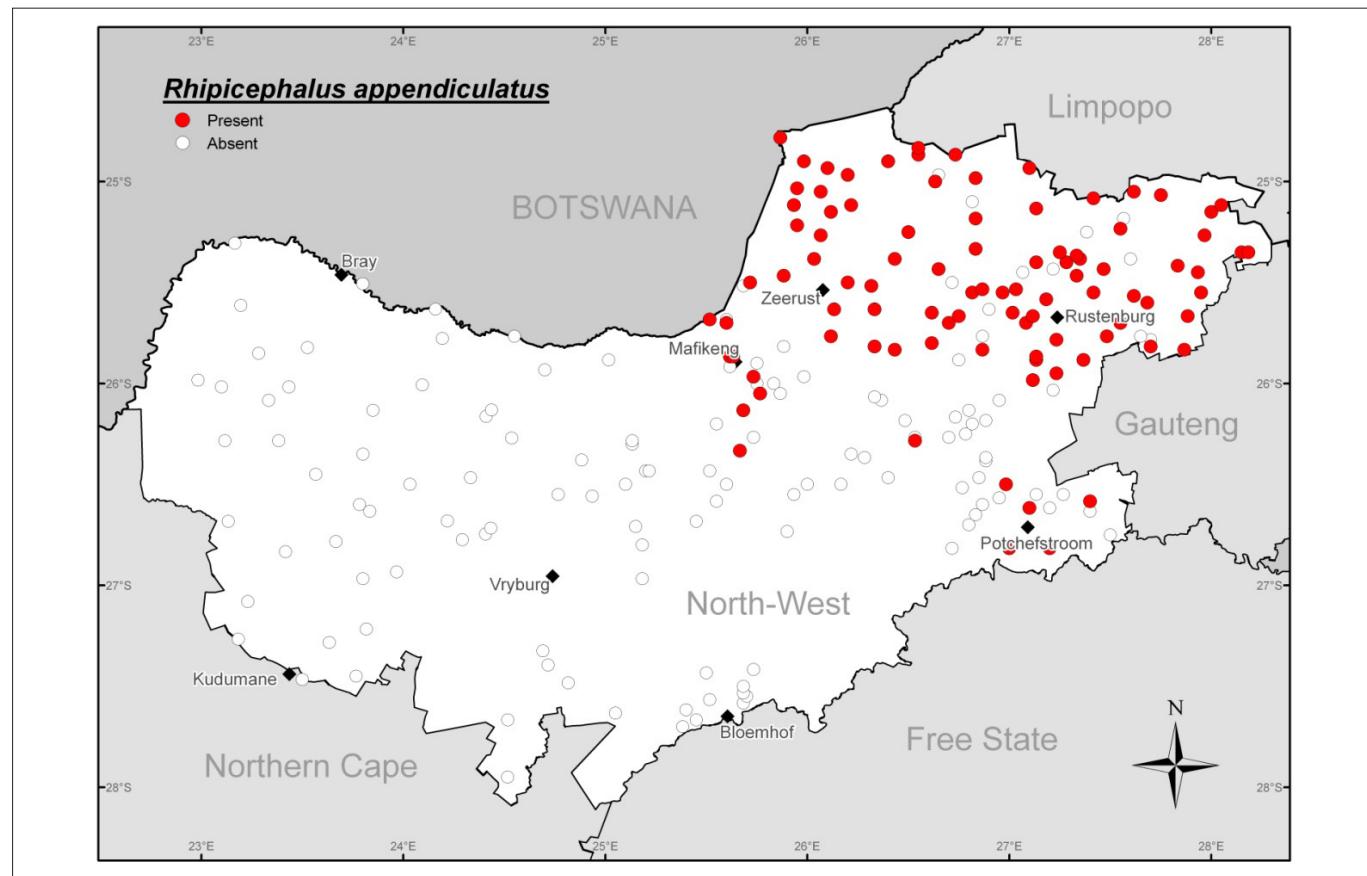


FIGURE 6: The geographic distribution of *Rhipicephalus appendiculatus* in the North West province, South Africa.

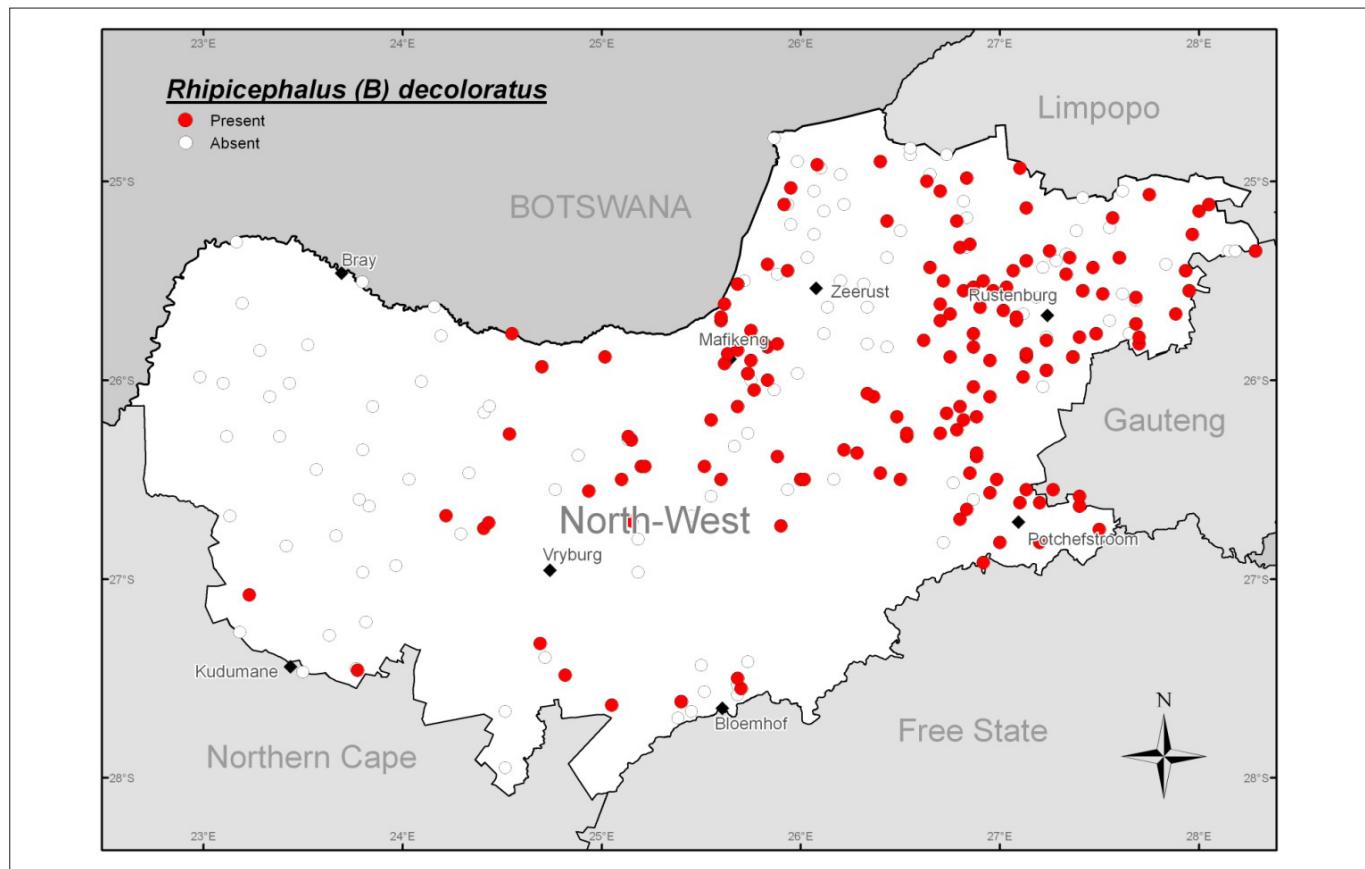


FIGURE 7: The geographic distribution of *Rhipicephalus (Boophilus) decoloratus* in the North West province, South Africa.

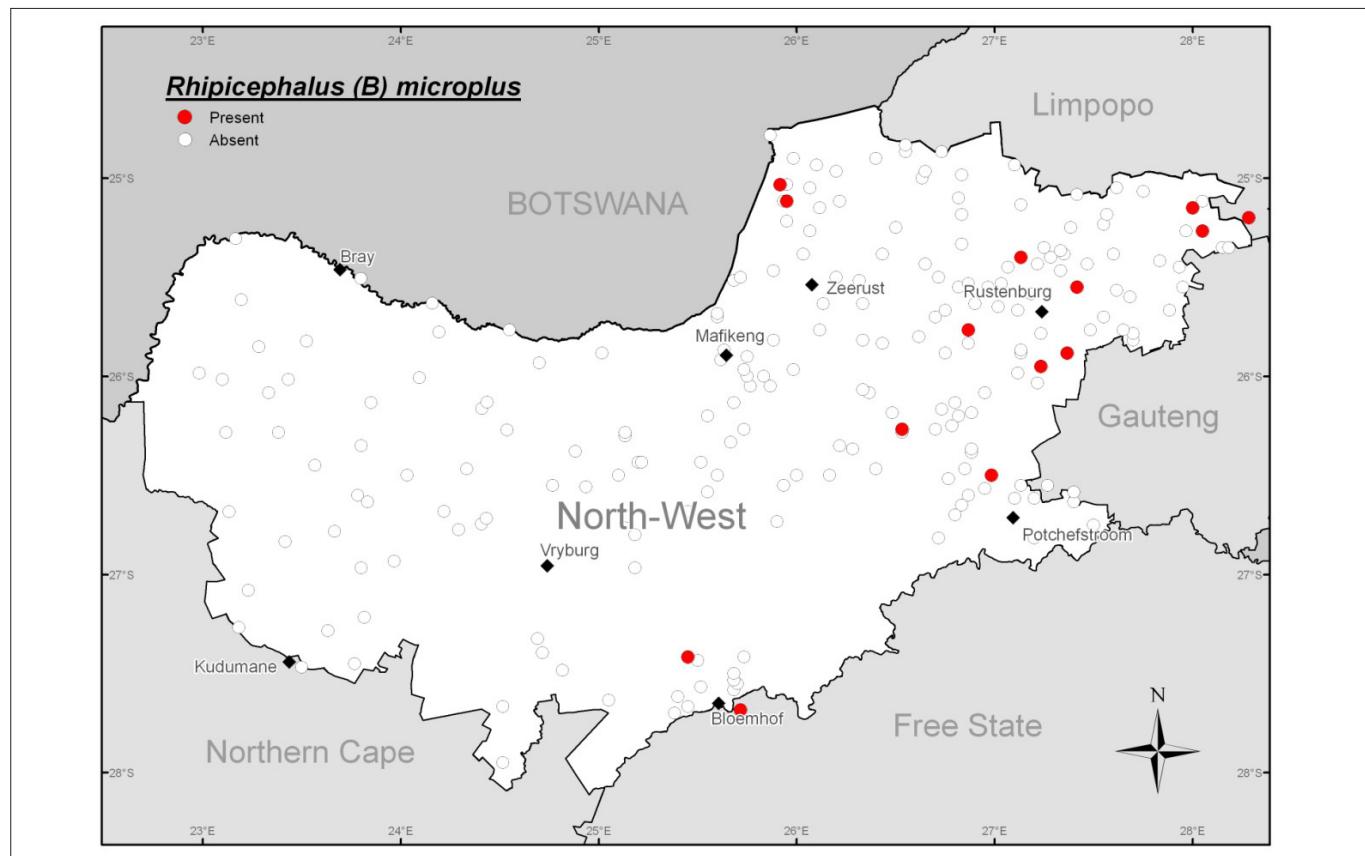


FIGURE 8: The geographic distribution of *Rhipicephalus (Boophilus) microplus* in the North West Province, South Africa.

species is absent in game parks, where no cattle occur (Horak *et al.* 1986). Recently, goats have been implicated as alternate hosts for this species, but in the presence of cattle in order to maintain populations (Nyangiwe & Horak 2007). In the present survey 81.8% of *R. (B.) microplus* specimens were collected from cattle and, significantly, a relatively high 7.7% were found on goats. None were found on sheep. The remaining 10.5% of the collected *R. (B.) microplus* specimens were not assigned a host by the collectors, but were most probably collected off cattle.

The seasonality of *R. (B.) microplus* was similar to that of *R. (B.) decoloratus*, with peak numbers occurring during the autumn months of April and May.

Rhipicephalus evertsi evertsi

R. evertsi evertsi is widely distributed and common on livestock throughout much of Africa, occurring in desert, steppe, savanna and temperate climatic regions (Walker *et al.* 2003). It has the most widespread distribution of species in the genus *Rhipicephalus* in Africa and has an extensive host range (Walker *et al.* 2000). It was the most commonly collected species in the North West province (31.5% of all specimens), being distributed over the whole province and absent at only two collection sites (Figure 9). In this survey, the adults that were collected came from cattle (79.1%), goats (15.9%) and sheep (3.9%), whilst the remaining 1.1% were unaccounted for as to host. Peak activity was recorded early in autumn (May), although high numbers were also recorded during the summer months.

Rhipicephalus evertsi mimeticus

Although of minimal economic importance, this species is interesting in that it is recorded as occurring in the arid regions of Angola, Namibia and Botswana (Theiler 1962). With regard to morphology and biology it is very similar to its subspecies *R. evertsi evertsi* and can also cause paralysis in sheep, mainly lambs, owing to secreting a toxin in the saliva whilst feeding (Gothe 1999).

This species has infiltrated the North West province, with suitable habitat conditions enabling it to establish populations in the western region (Figure 10), possibly by means of sheep introduced from Botswana or Namibia, and thus likely displacing *R. evertsi evertsi* at these localities. Recurring monthly collections of relatively high numbers off sheep from these sites confirmed the establishment of viable *R. evertsi mimeticus* populations. Being subspecies, *R. evertsi mimeticus* and *R. evertsi evertsi* should interbreed, yet both were found to be morphologically distinct and could easily be distinguished taxonomically at the same localities, which may indicate some degree of speciation. This observation needs further investigation.

Rhipicephalus simus

This species establishes in regions with a savanna climate and is never encountered in high numbers (Norval & Mason 1981; Walker *et al.* 2000). It is well established in the bushveld areas of the north-eastern region of the province to which its distribution is confined (Figure 11). Of the *R. simus* collected,

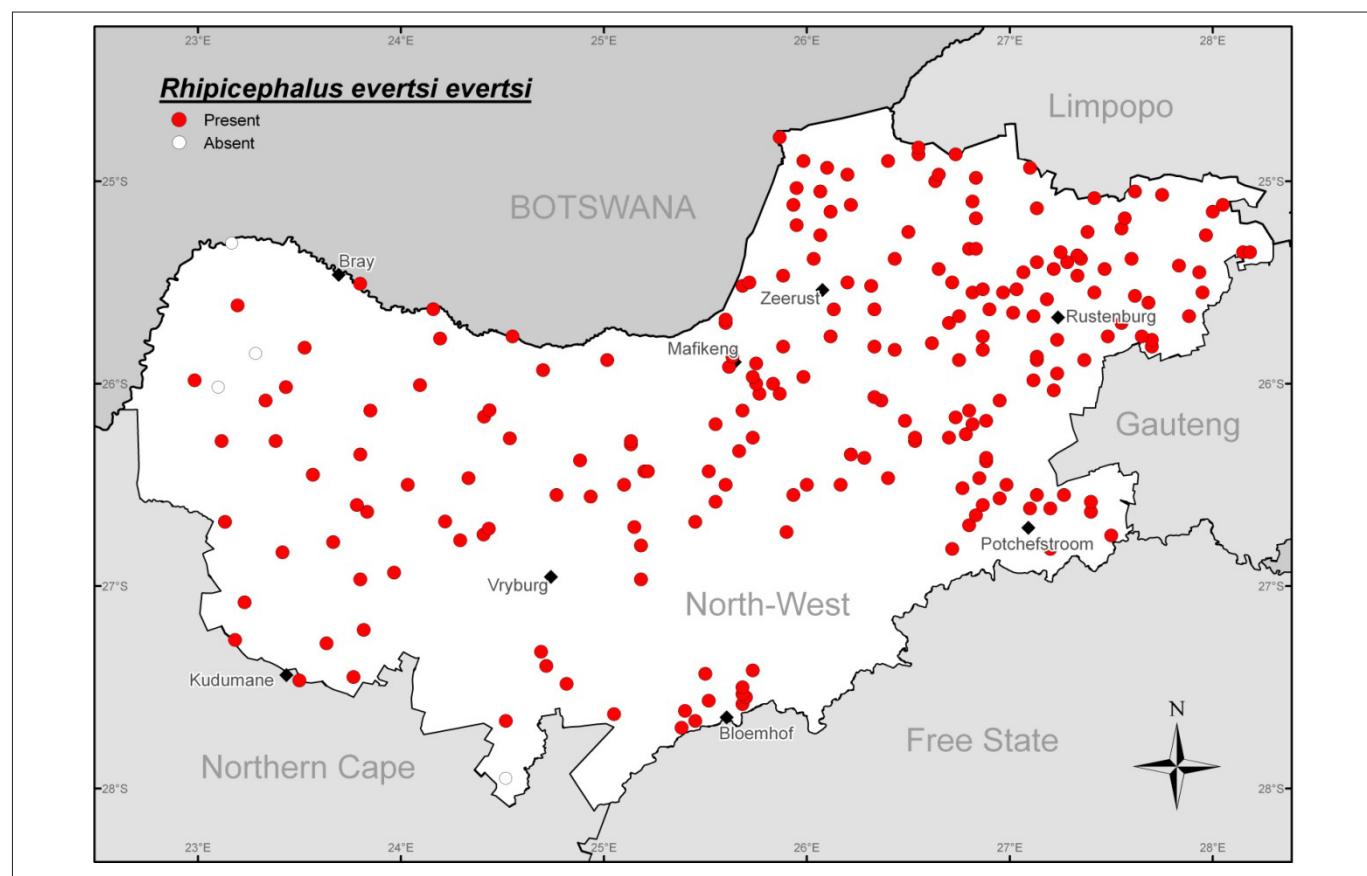


FIGURE 9: The geographic distribution of *Rhipicephalus evertsi evertsi* in the North West province, South Africa.

71.9% were from cattle, 4.0% from sheep and 18.5% from goats. This species was also recovered from dogs (4.0%), whilst 1.6% were not assigned a host by collectors.

Tick-borne disease serology

As shown in Figures 7 and 8, *R. (B.) decoloratus* and *R. (B.) microplus* occurred sympatrically at some localities in the north-eastern region of the province. Both species are associated with the transmission of the causative organism of anaplasmosis (*Ana. marginale*) as well as the organisms causing bovine babesiosis (*Babesia bigemina* and *Babesia bovis*) (De Vos & Potgieter 1994). The antibody status of cattle herds to these tick-borne pathogens in the areas of sympatric distribution of these two tick vector species, as well as the presence (or absence) of the two tick vector species is shown in Table 3.

The results indicate that only one property (Commiesiedrift) is in a state of endemic stability (Norval *et al.* 1983) to *B. bigemina* (100%), whereby sufficient infected vector ticks (*R. (B.) decoloratus*) are present to transmit the pathogen such that all the animals show an antibody response indicative of disease immunity. All other properties appear to experience endemic instability to both *B. bigemina* and *B. bovis*, strongly suggesting that intensive chemical control is practiced on these properties, thereby reducing vector challenge and, subsequently, pathogen transmission. On the endemically unstable properties, more than 40% of the cattle show no

antibodies to the causative organisms and are thus fully susceptible and at risk to babesiosis should they be challenged by infected ticks.

None of the animals on six properties showed antibodies to *B. bigemina* despite the presence of the tick vector, possibly owing to uninfected ticks (unlikely) or extremely stringent tick control practices. These animals could be completely susceptible to bovine babesiosis should they be challenged by infected ticks. *R. (B.) microplus* was absent on five of these properties and, as expected, none of the animals tested positive for *B. bovis* antibodies. However, on one of the properties (Leeukraal) on which no animals tested positive for *B. bigemina* in the presence of the tick vector, 50% of the animals tested positive for *B. bovis* in the presence of the vector tick. The latter case is difficult to explain: it is possible that *R. (B.) microplus*, as a vector, presented a much higher challenge than did *R. (B.) decoloratus* and that antibody manifestation to *B. bigemina* was subsequently lost. On two properties, respectively 28% and 40% of the animals showed antibody titres to *B. bovis*, indicative of *R. (B.) microplus* infestation, although this vector tick was not collected at the time of the survey.

Conclusion

This study was conducted to survey the occurrence and distribution of ticks infesting livestock in the North West province of South Africa. The survey entailed the monthly collection of tick specimens from livestock hosts at specified

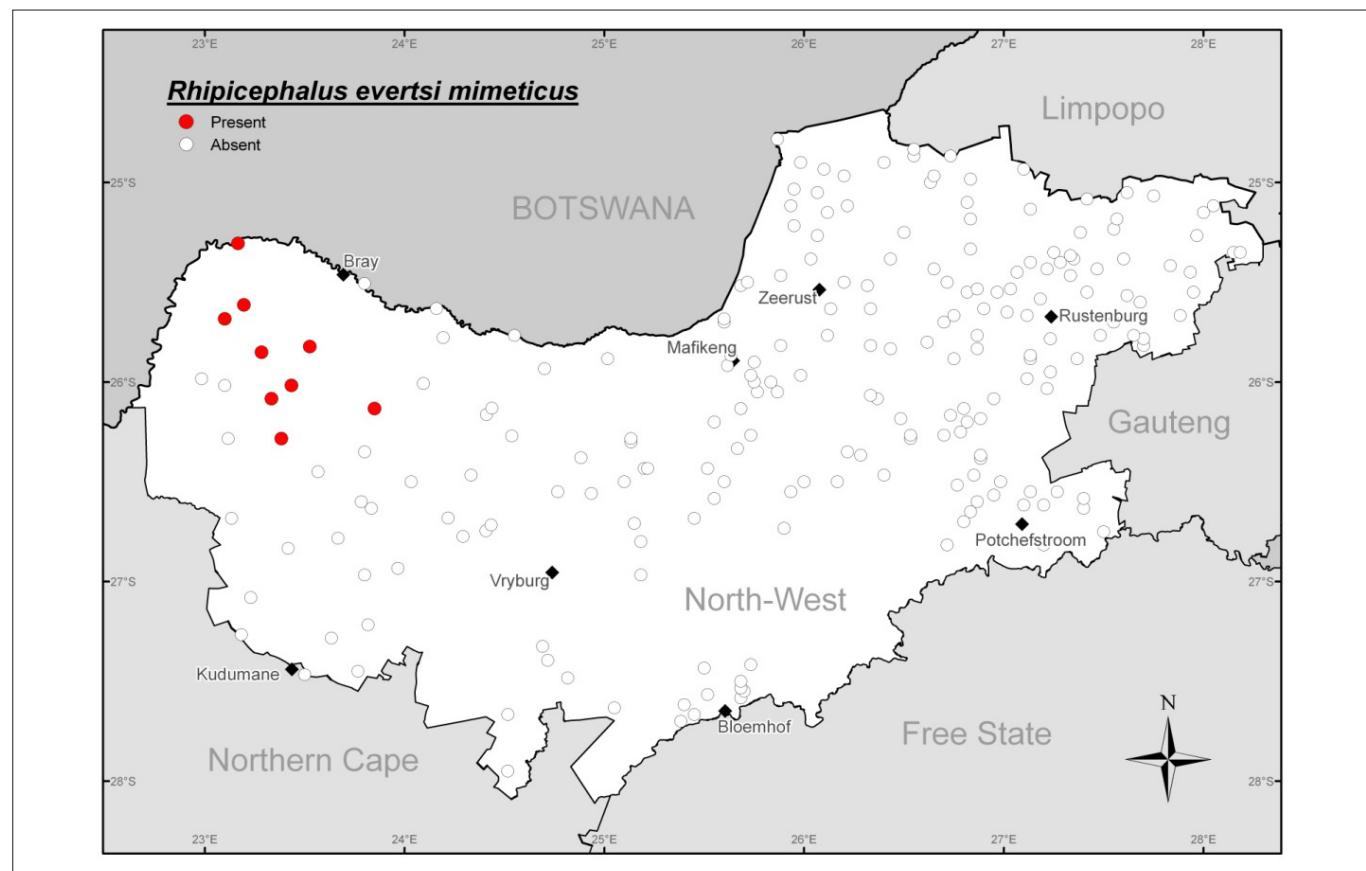


FIGURE 10: The geographic distribution of *Rhipicephalus evertsi mimeticus* in the North West province, South Africa.

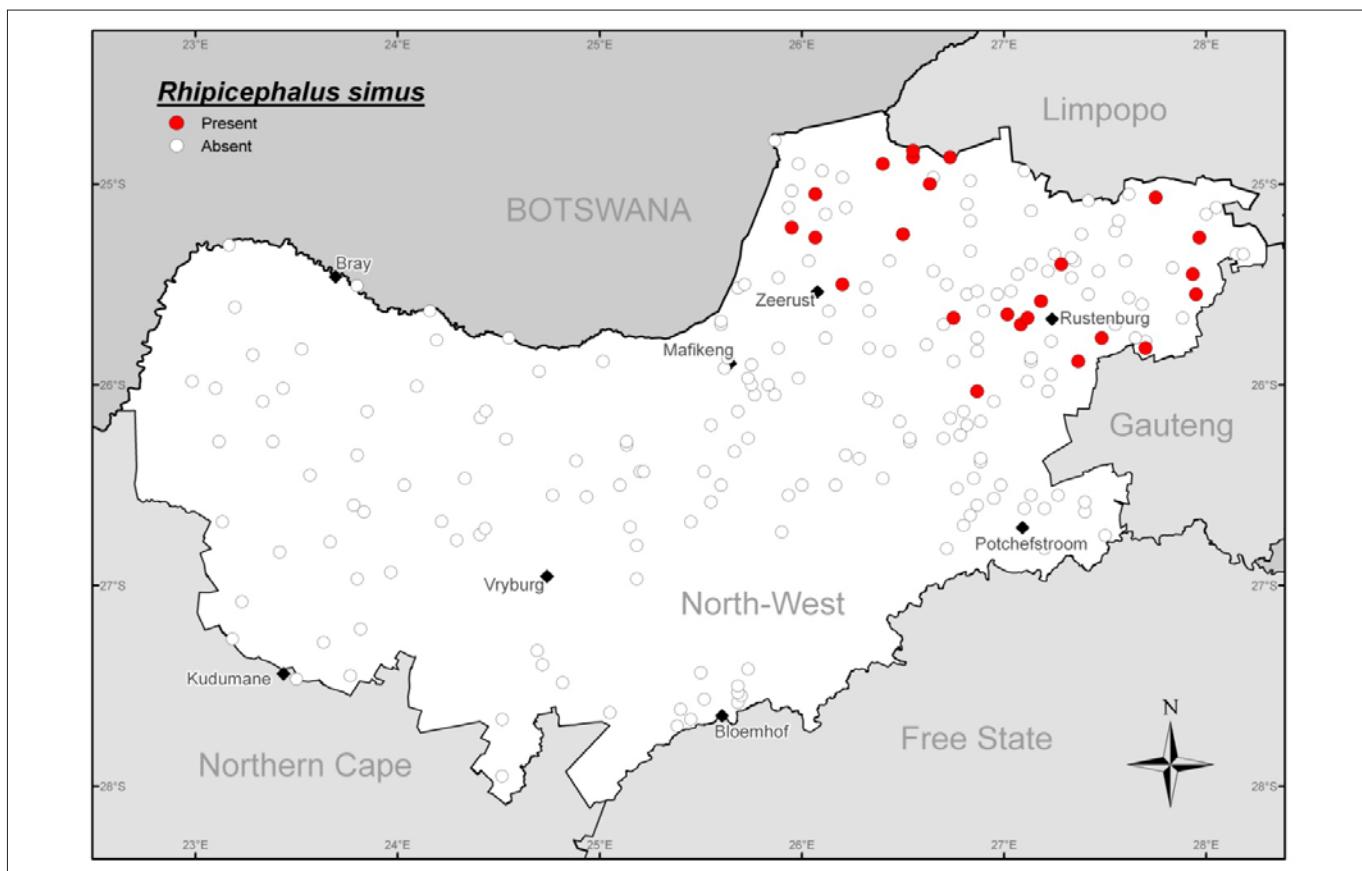


FIGURE 11: The geographic distribution of *Rhipicephalus simus* in the North West province, South Africa.

TABLE 3: Serology results from livestock at various localities and associated presence or absence of vectors.

Locality	State veterinary area	Longitude (South)		Latitude (East)		Serology: Positive titres (%)			Vector presence	
		Degree	Minutes	Degree	Minutes	<i>B. bovis</i>	<i>B. bigemina</i>	<i>Anaplasma</i>	BMIC	BDEC
Brakfontein 132	Lehurutshe	24	58	26	11	0	30	20	0	1
Goedgelegen 250	Lehurutshe	25	31	26	18	0	20	50	0	1
Lekkerlacht 8	Lehurutshe	24	54	25	59	0	0	50	0	1
Moilwa 37 (Matlhase)	Lehurutshe	25	29	25	43	0	0	20	0	1
Boschplaas 91	Moretele	25	21	28	17	30	50	60	1	1
Leeukraal 54	Moretele	25	7	28	3	50	0	30	1	1
Bapong 458	Odi	25	43	27	41	45	25	50	1	1
Bethane 405	Odi	25	34	27	31	0	0	45	0	1
Kleinfonteinstad 247	Odi	25	27	25	56	28	48	40	0	1
Syferfontein 430	Odi	25	33	27	57	56	24	76	1	1
Basfontein 363	Rustenburg	25	53	27	8	0	50	70	0	1
Brakspruit 402	Rustenburg	25	37	26	42	40	100	20	0	1
Commiesiedrift 327	Rustenburg	25	48	27	14	0	10	30	0	1
Kwaggashoek 448JP	Rustenburg	25	48	26	37	0	0	75	0	1
Zandfontein 380	Rustenburg	25	57	27	14	33	8	42	1	1
Vlakplaats 407 JP	Swartruggens	25	39	26	35	0	17	Not done	0	1
Waterval 386JP	Swartruggens	25	33	26	49	0	35	Not done	0	1
Rhenosterfontein 494	Swartruggens	26	2	26	52	0	20	Not done	0	1
Krokodilfontein 217	Swartruggens	25	26	26	49	0	0	Not done	0	1

A positive reciprocal antibody titre is defined as exceeding 64.

Vector presence is denoted 1; vector absence is denoted 0.

Anaplasma, *Anaplasma marginale*; *B. bigemina*, *Babesia bigemina*; *B. bovis*, *Babesia bovis*; BDEC, *Rhipicephalus (B.) decoloratus*; BMIC, *R. (B.) microplus*.

sites in the north-eastern, central and western regions of the province. Tick specimens were subsequently identified and the distributions of the major species plotted.

According to this survey, livestock in this province harbour 22 tick species (18 ixodids; 4 argasids). The major tick-borne

diseases were prevalent mainly in the north-eastern region, which also displayed the highest tick species diversity.

The vectors of Corridor disease (buffalo-associated *Theileria parva*), namely *R. appendiculatus* and *Rhipicephalus zambeziensis* were present in the north-eastern region of the



province, which indicates that care should be exercised in the introduction of Corridor-infected buffalo in these regions. The central region appears transitory to the major vectors *A. hebraeum* and *R. (B.) decoloratus*, whilst the two *Hyalomma* vectors of Crimean–Congo haemorrhagic fever virus are widespread over the whole province. The north-western area (Bray) of the western region has been infiltrated with *R. evertsi mimeticus*, a species considered to be non-endemic to South Africa. Most herds sampled for serology in areas endemic for babesiosis and anaplasmosis in the north-eastern region are endemically unstable and at risk to these tick-borne diseases should vector control measures become ineffective.

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