Population dynamics of ticks (Acari: Ixodidae) infesting cattle in the central region of the Eastern Cape Province, South Africa

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Abstract

Ticks are widely distributed throughout the world, especially in tropical and subtropical areas. Globally, costs associated with ticks and tick-transmitted pathogens in cattle range between US$ 22-30 billion. This study was carried out from April 2016 to March 2017 to identify the tick species from 10 cattle and also from six drag samples during the 12-month period. All ticks collected per animal and from vegetation were stored in labelled sample tubes containing 70% ethanol. A total of 2 391 ticks were collected during the study. Based on morphological traits, 10 tick species were identified: *Amblyomma hebraeum* (36.6%), *Rhipicephalus evertsi evertsi* (18.0%), *R. (Boophilus) decoloratus* (16.3%), *Hyalomma rufipes* (12.7%), *R. appendiculatus* (8.9%), *R. simus* (6.7%), *Ixodes pilosus* (0.5%), *R. follis* (0.3%), *Haemaphysalis elliptica* (0.04%) and *H. silacea* (0.04%). Significantly more larvae of R. (B.) decoloratus were collected from the vegetation than on cattle. No collection of the invasive cattle tick, R. (B.) *microplus* was found in the study area. The absence of R. (B.) *microplus* is of epidemiological interest in terms of tick distribution, as this species is known to be highly resistant to numerous acaricide compounds.

Keywords: Cattle, Eastern Cape Province, hard ticks, pathogens, Rhipicephalus (Boophilus) decoloratus

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Introduction

In Eastern Cape Province, most farmers depend on their livestock for survival and cattle are primarily used as source of income from the sale of animal products (meat, milk and hide) and live animals. Livestock sector in the province is constrained by ticks and tick-borne diseases (TBDs) that cause significant economic losses. Ticks are responsible for severe losses caused either by the effect of blood loss, tick worry, damage to hides and skins and the injection of toxins or through mortality and morbidity caused by the diseases they transmit. A current estimate of economic losses from ticks and TBDs globally is approximately US$20-30 billion per annum (Lewis-Tabor & Rodrguez Valle 2016). In Africa, the economic losses due to ticks and TBDs is estimated to US$ 160 million per annum (Dold & Cocks 2001). Of the annual costs reported in Africa, South Africa is responsible for US$ 92 million per annum. This is very huge losses for the country (nearly 60%) and is more impacting on the small-scale and communal farming areas (Mapholi *et al.*, 2014).

Several tick species are widely distributed throughout the world particularly in tropical and sub- tropical countries. Globally, there are about 900 species documented in three families. About 700 species belong to the family Ixodidae (hard ticks), 199 belong to the Argasidae (soft ticks) and only one species belongs to the Nuttalliellidae (Jongejan & Uilenberg 2004; Guglielmone *et al.*, 2010). As far as livestock is concerned, the significance of the ixodid ticks is far greater than the argasid ticks, even though the latter contains important disease vectors in the genera Ornithodoros and *Argas*. There are approximately 90 different hard tick species in South Africa, of which only four are significant pathogenic for cattle (Norval & Horak 2004; Nyangiwe et al. 2011; Spickett *et al.,* 2011). These four are: *Amblyomma hebraeum*, vector of *Ehrlichia ruminantium*, the causative organism of heartwater; *Rhipicephalus appendiculatus*, vector of *Theileria parva*, the causative organism of East Coast fever and Corridor disease; *Rhipicephalus decoloratus*, vector of *Babesia bigemina*, the causative organism of African redwater and gallsickness and *Rhipicephalus microplus*, vector of both *Babesia bovis*, the causative organism of Asiatic redwater, African redwater and Gallsickness (Nyangiwe *et al.,* 2011).

In Eastern Cape Province, particularly in the central region, there are few studies showing prevalent tick species and their distribution in the regions. The report mentioned by Masika, Sonandi & Van Averbeke (1997) was based on the tick control methods by small-scale cattle farmers in the central region. Only few studies by Yawa *et al.* (2018, 2019) that reported about ecological preferences and tick dynamics under three-ecological zones. In this paper, we present the seasonal activities and dynamics of tick populations infesting cattle in the central region of the Eastern Cape Province.

Materials and methods

The study was conducted at Adelaide Research Station which is situated at 26°18′E longitude and 32°42′S latitude and is at 740 m above the sea level. The vegetation is classified as Bedford Dry Grassland (BDG) and characterized by medium height grasslands that are interspersed by Acacia karoo woodlands. The area contains dwarf shrubby component of karroid origin in South Western parts. The annual minimum rainfall is 350 mm with a maximum of 550 mm. Temperature varies among seasons, and range from 29–32 to 4–6 °C. The dominating grass species are *Digitaria argyrograpta, Eragrostis curvula, Eragrostis capensis, Pentzia globosa, Tragus koelerioides, Eragrostis plana, Cyperus usitatus, Cymbopogon excavatus, Helichrysum rugulosum, Tephrosia capensis, Gazania krebsiana, Pelargonium sidoides, Berkheya species, Lycium cinerium, Themeda triandra, Hermannia althaefolia* and *Melolobium burchelli* (Mucina & Rutherford 2006).

Two sampling techniques were used in the study: (a) removal of feeding ticks from their hosts, (b) collection of ticks from vegetation.

The collections were carried out by a trained team. Ticks were randomly collected monthly from ten cattle during the 12-month period. Tick collection on cattle was done before dipping. During tick sampling, cattle were restrained in a crush pen. Ticks were collected mainly from right side of the animal; that is from half of the head and in one ear, and also from the whole of the upper perineum and tail brush.

Ticks questing for host on vegetation were collected on a monthly basis by drag-sampling as described by Nyangiwe *et al.* (2011). Briefly, ten flannel strips (100 cm × 10 cm) were attached next to each other on a 120-cm-long wooden spar with Velcro tape and the two ends of a twine harness were tied to the tips of the spar. At each sampling camp, six replicate drags of 100 m, approximately 50 m apart, were performed at monthly intervals. After each drag, all ticks on the flannel strips were removed using forceps and stored in 70% ethanol in a labelled glass vials for later identification and counting. Ticks were identified at genus and species level using a standard stereomicroscope. A manual guide of tick identification by Walker *et al.* (2003) was used to identify the different adult tick species. The larvae of multi-host species were identified using the descriptions by Arthur (1973, 1975) and Walker *et al.* (2000) whereas the larvae of R. (B.) decoloratus were identified using the descriptions of Gothe (1967). Moreover, for larval identification, reference specimens provided by Prof Horak from the University of Pretoria tick museum were used. Drags were done during sunny days between 10h00 and 16h00 to avoid poor tick collections.

The data for questing and adult ticks was analysed using Statistical Analysis System version 9.1 (SAS, 2003). Interaction between vegetation types and season on tick counts was determined using the generalised linear model procedures for repeated measures of SAS (2003).

Statistical significance was tested at 95% level with all results with $P < 0.05$ considered to be statistically significant.

Results

A total of 1 955 adult ticks were collected from 120 cattle, and 436 free-living ticks were collected on vegetation in the study area (Table 1). Of the grand total of 2 391 adult ticks collected, five different genera, namely *Rhipicephalus* including sub-genus *Boophilus, Amblyomma, Hyalomma, Ixodes* and *Haemaphysalis*. *Rhipicephalus* (50.19%) was the most abundant and widely distributed genus followed by Amblyomma (36.56%) in all study sites and *Haemaphysalis* (0.08%) was the least (Table 1).

Table 1 Tick genera identified in the study area

Genus	No. of ticks collected	Prevalence (%)
Rhipicephalus (Boophilus)	1200	50.19
Amblyomma	874	36.56
Hyalomma	304	12.71
Ixodes	11	0.46
Haemaphysalis	2	0.08
Total	2 391	100

Amblyomma hebraeum (36.6%) was the most abundant tick species identified followed by R. *evertsi evertsi* (18.0%), while ticks of the genus *Haemaphysalis (H. elliptica and H. silacea*) were the least abundant tick species (0.04%) (Table 2). For ticks collected in cattle, there was high count for A. *hebraeum* (0.69 ± 0.062 females and 0.76 ± 0.062 males) and H. *rufipes* (0.48 ± 0.045 females and 0.39 ± 0.051 males) during summer compared to other seasons (Table 3). All tick species from cattle significantly ($P < 0.05$) differ among seasons. From the vegetation, no significant differences ($P > 0.05$) were observed between the larvae of A. *hebraeum*, H. *rufipes*, R. *evertsi evertsi* and the nymphs of R. *appendiculatus* (Table 4). Significant differences ($P < 0.05$) were observed between the larvae of R. *appendiculatus* and R. (B.) decoloratus. However, larvae of the one-host tick, R. (B.) decoloratus were significantly ($P < 0.05$) different throughout the seasons.

Table 2 The overall tick counts collected from cattle and vegetation

Tick species	Adult ticks		Larvae		Nymphs	
	Counts	Prevalence (%)	Counts	Prevalence (%)	Counts	Prevalence (%)
Amblyomma hebraeum	856	43.90	18	4.54	0	0.00
Haemaphysalis silacea	0	0.00	1	0.25	0	0.00
Haemaphysalis elliptica	0	0.00	1	0.25	0	0.00
Hyalomma rufipes	298	15.28	6	1.52	0	0.00
Rhipicephalus appendiculatus	117	6.00	55	13.89	40	100
Rhipicephalus (Boophilus) decoloratus	175	8.97	213	53.79	0	0.00
Rhipicephalus evertsi evertsi	336	17.23	95	23.99	0	0.00
Rhipicephalus simus	159	7.90	2	0.50	0	0.00
Rhipicephalus follis	5	0.26	3	0.76	0	0.00
Ixodes pilosus group	9	0.46	2	0.51	0	0.00
Total	1955	100	396	100	40	100

Table 3 Least square mean of season on engorged A. *hebraeum*, H. *rufipes* R. *appendiculatus*, R. (B.) *decoloratus*, R. *evertsi evertsi*, R. *simus* and *Ixodes pilosus* group collected from cattle

	Tick species													
Seasons	A. heb		H. ruf		R. app		R. dec		R. eve		R. sim		Ix. pil	
	F	M	F	M	F	M	F	M	F	M	F	M	F	M
Autumn	0.48^{b}	0.66^{a}	0.27^{b}	0.24^{ab}	0.12^{b}	0.06^{ab}	0.25^{ab}	0.02^{b}	0.25^{ab}	0.26^{a}	0.11^{b}	0.11^{a}	0.32^{a}	0.43^{a}
Spring	0.26^{c}	0.32^{b}	0.10^{c}	0.13^{b}	0.09^{b}	0.10^{ab}	0.25^{ab}	0.10^{ab}	0.25^{ab}	0.31^{a}	0.10^{b}	0.11^{a}	0.29^{a}	0.19^{b}
Summer	0.69^{a}	0.76^{a}	0.48^{a}	0.39^{a}	0.24^{a}	0.14^{a}	0.33^{a}	0.21^{a}	0.33^{a}	0.32^{a}	0.25^{a}	0.18^{a}	0.32^{a}	0.30^{ab}
Winter	0.36^{bc}	0.48^{b}	0.09^{c}	0.15^{b}	0.01^{b}	0.01^{b}	0.13^{b}	0.05^{b}	0.13^{b}	0.41^{a}	0.10^{b}	0.12^{a}	0.23^{a}	0.28^{ab}
SEM	0.062	0.064	0.045	0.051	0.041	0.033	0.046	0.032	0.046	0.054	0.042	0.041	0.064	0.061

SEM, Standard error of means; A. heb – Amblyomma hebraeum, H. ruf – Hyalomma rufipes, R. app – Rhipicephalus appendiculatus, R. dec – Rhipicephalus (Boophilus) decoloratus, R. eve – Rhipicephalus evertsi evertsi, R. sim – Rhipicephalus simus and Ix. pil – Ixodes pilosus group. abcdMeans in the same column with different superscripts differ significantly (P <0.05)

Table 4 Least square mean (±Standard error) of season on free-living A. *hebraeum*, H. *rufipes*, R. *appendiculatus*, R. (B.) *decoloratus* and R. *evertsi evertsi* larvae collected from Bedford Dry Grassland

SEM, Standard error of means; A. heb – Amblyomma hebraeum, R. app – Rhipicephalus appendiculatus, R. dec – Rhipicephalus (Boophilus) decoloratus and R. eve – Rhipicephalus evertsi evertsi. abcde Means in the same column with different superscripts differ significantly (P <0.05).

	Tick species					
Season	A. heb	H. ruf	R. app	R.app (Nymph)	R. dec	R. eve
Autumn	0.06^{a}	0.02^{a}	0.00^{b}	0.21^{a}	0.40^{b}	0.24^{a}
Spring	0.10^{a}	0.03^{a}	0.31^{a}	0.08^{a}	0.65^{a}	0.17^{a}
Summer	0.05^{a}	0.00^{a}	0.11^{b}	0.10^{a}	0.46^{ab}	0.36^{a}
Winter	0.00^{a}	0.03^{a}	0.14^{b}	0.10^{a}	0.38^{b}	0.17^{a}
SEM	0.039	0.023	0.059	0.053	0.077	0.074

Discussion

The current study indicated that the major genera of ticks infesting cattle in Eastern Cape Province belong to *Rhipicephalus* including subgenus (*Boophilus*), *Amblyomma*, and *Hyalomma* in order of predominance. Similar observations were reported by previous studies (Moges *et al.*, 2012; Yawa *et al.*, 2018). According to Walker (1991) the genus *Rhipicephalus* is the largest genus in southern Africa, and it is the fourth largest in the family Ixodidae (Walker *et al.*, 2000), and there are above 70 tick species identified under this genus (Olwoch et al. 2007). The great majority of the species are three-host ticks of Afrotropical origin, but a few have a two-host or one-host cycle. The *Rhipicephalus* species with a one-host tick parasitic cycle belong to the subgenus *Boophilus* (formerly regarded as an independent genus of *Rhipicephalus*) which is of paramount importance for cattle industry in tropical and subtropical areas worldwide (Horak *et al.*, 2002). Subgenus *Boophilus* ticks are small and they lack ornamentation.

One species, R. (B.) *decoloratus* is widely distributed in South Africa but it has been displaced by the invasive cattle tick, R. (B.) microplus, where the two species co-exist (Nyangiwe *et al.*, 2013).

In the present study, A. *hebraeum* was the most abundant tick species (36.6%), and similar results had been reported by Yawa et al. (2018, 2019) and Horak *et al.*, (2009). A. *hebraeum* is the South African bont tick and has a great economic importance, because it transmits *Ehrlichia ruminantium*, the organism causing heart water in cattle (Norval & Horak 2004; Horak *et al.*, 2015). A. *hebraeum* needs moisture and warmth, brush and bush and does not survive in open grassland (Walker *et al.,* 2003; Norval & Horak 2004). In South Africa, it occurs along the coastal belt from Port Elizabeth in the Eastern Cape Province, through KwaZulu-Natal and onward across Mpumalanga, Gauteng, Limpopo and North-West Provinces (Nyangiwe *et al.*, 2011). The present collection of A. *hebraeum* is within the previous reported areas and seems to expand its range in the Eastern Cape Province. R. *evertsi evertsi* was the second most abundant (18.0%) and widely distributed tick species in the area. These findings are in agreement with previous studies (Nyangiwe *et al.,* 2011; Yawa *et al.,* 2018) who reported about the high prevalence of this tick collected on cattle in the province. The tick is a two-host tick and is common on livestock species throughout much of Africa. In Chilga district, north-west of Ethiopia, Moges *et al.* (2012) reported R. *evertsi evertsi* as widespread tick collected on cattle. It is found throughout the year in South Africa and this has been confirmed in the present study where it was collected in all seasons from the cattle.

Rhipicephalus (Boophilus) decoloratus is a one-host tick infesting domestic and wild ruminants. R. (B.) *decoloratus* was present on cattle throughout the year with a peak in abundance during autumn, spring and summer. This is an indigenous tick which has seasonal periodicity during warmer months (Norval & Horak 2004; Latif & Walker 2004). In the present survey, R. (B.) *decoloratus larvae* was found in all seasons from the vegetation with peak of activity during spring (0.65 ± 0.08). This is similar with the findings of Phalatsi *et al.* (2004), who observed high hatching of the larval progeny during spring. The increase on larval progeny from the vegetation in spring can be ascribed to the laying of eggs during autumn and overwinter, where, in response to a rise in temperature, the eggs synchronously hatch in spring (Nyangiwe *et al.,* 2011). Eastern Cape Province is known for the prevalence of the southern cattle tick, R. (B.) microplus, which was reported to displace the native tick, R. (B.) *decoloratus* (Horak et al. 2009, Nyangiwe *et al.,* 2013). Surprisingly no collection of R. (B.) microplus was made on host and from the vegetation. Low rainfall and semi-arid nature of the study area could be the reason behind this absence of the R. (B.) microplus. Similarly, Yawa *et al.* (2018, 2019) did not collect any R. (B.) microplus during their survey in the Eastern Cape Province.

Hyalomma rufipes is a two-host tick infesting domestic animals such as cattle, horses, sheep and goats including large wild animals. In the study area, H. *rufipes* was found in higher numbers on cattle during summer. It was collected in very low numbers from the vegetation because the larvae of this tick are hunters and are not questing for the host. Both R. *appendiculatus* (8.9%) and R. *simus* (6.7%) are three-host ticks which were the fifth and sixth abundant ticks. Their prevalence is average because they are restricted to higher rainfall regions and the study area has an annual minimum rainfall of 350 mm with a maximum of 550 mm (Mucina & Rutherford 2006). The other ticks (I. *pilosus*, R. *follis*, H. *elliptica* and H. *silacea*) were less commonly collected and this was similar to other surveys where these species were in low numbers (Nyangiwe *et al.*, 2011; Horak *et al.,* 2015; Yawa *et al.,* 2018).

Conclusion

Ticks cause severe economic losses in cattle farming areas and the seasonal occurrence of ticks can provide useful information to control the pathogens they transmit. This study provides evidence that economically important ticks are widespread throughout the study area and their prevalence in abundance is alerting. However, for the effective tick control strategies, more information on the seasonality of tick species is required and should be incorporated into future studies.

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Authors' contributions

N.N and N.S planned the survey. N.N. was the project leader, drafted and revised the manuscript. N.N. and M.Y. identified the ticks that had been collected by N.S, M.Y. and S.G. Both M.Y and S.G analysed the data and revised the manuscript. All authors read and approved the manuscript.

Conflict of interest declaration

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

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