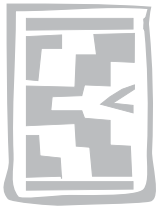

Goats as alternative hosts of cattle ticks

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ABSTRACT

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The objective of this study was to compare the presence on goats and cattle of adult ticks that usually infest cattle. To this end ticks collected from sets of five goats were compared with those collected from sets of five cattle at 72 communal dip-tanks in the eastern region of the Eastern Cape Province. *Amblyomma hebraeum* was present on goats at 25 and on cattle at 39 dip-tanks, and a total of 61 goats and 138 cattle were infested. Adult *Rhipicephalus* (*Boophilus*) *microplus* was present on goats at 48 and on cattle at 69 dip-tanks, and a total of 113 goats and 242 cattle were infested. The lengths of 84 of 148 female *R.* (*Boophilus*) *microplus* collected from the goats exceeded 5 mm or more, indicating that they could successfully engorge on these animals. The differences between the proportions of dip-tanks at which *A. hebraeum* or *R.* (*Boophilus*) *microplus* was present on goats and cattle and also between the proportions of goats and cattle that were infested were significant (Chi-square test, $P < 0.01$). Adult *Rhipicephalus appendiculatus* was present on goats at 70 and on cattle at 67 dip-tanks, and a total of 296 goats and 271 cattle were infested. The proportion of dip-tanks at which cattle were infested did not differ significantly from the proportion of tanks at which goats were infested (Fischer's exact probability test, $P = 0.44$), but the proportion of infested cattle was significantly lower than the proportion of infested goats (Chi-square test, $P < 0.05$). Adult *Rhipicephalus evertsi evertsi* was present on goats and cattle at all 72 sampling localities, and a total of 334 goats and 316 cattle were infested. The proportion of infested cattle was significantly lower than the proportion of infested goats (Chi-square test, $P < 0.05$). These results underscore the necessity of including goats in any tick control programme designed for cattle at the same locality.

Keywords: Adult ixodid ticks, alternative hosts, *Amblyomma hebraeum*, cattle, Eastern Cape Province, goats, *Rhipicephalus* (*Boophilus*) *microplus*, *Rhipicephalus appendiculatus*, *Rhipicephalus evertsi evertsi*

IINTRODUCTION

Four tick species are of major economic importance as vectors of diseases that affect domestic cattle in southern Africa. These are *Amblyomma hebraeum*, the vector of *Ehrlichia* (*Cowdria*) *ruminantium*, the cause of heartwater in cattle, sheep, goats and certain wild ruminant species (Allsopp, Bezuidenhout & Prozesky 2004), *Rhipicephalus* (*Boophilus*) *decoloratus*, the vector of *Babesia bigemina*, the cause of babesiosis or African redwater in cattle (De Vos, De Waal & Jackson 2004), *Rhipicephalus* (*Boophilus*) *microplus*, an introduced tick, which is responsible for the transmission of both *B. bigemina* and *Babesia bovis*, the latter the cause of Asiatic redwater in cattle (De Vos *et al*. 2004), and *Rhipicephalus appendiculatus*, the vector of *Theileria parva*, the cause of

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theileriosis in cattle (Lawrence, Perry & Williamson 2004a, b). A fifth tick, *Rhipicephalus evertsi evertsi*, which is a vector of *Babesia caballi* and *Theileria equi*, the cause of piroplasmosis in horses (De Waal & Van Heerden 2004), has a preference for horses in all its stages of development, but is also a common parasite of cattle, goats and sheep (Norval 1981; Walker, Keirans & Horak 2000).

Several surveys have been conducted on the ticks that infest cattle and goats in South Africa. Some of these have focused only on cattle (Baker & Ducasse 1967; Londt, Horak & De Villiers 1978; Schröder 1980) and others only on goats (Rechav & De Jager 1991; Boomker, Horak & Ramsay 1994; MacIvor & Horak 2003), while a third group have included both cattle and goats at the same locality and same time (Baker & Ducasse 1968; Rechav 1982; Horak, Knight & Williams 1991; Horak 1999; Bryson, Tice, Horak, Stewart & Du Plessis 2002a, b), or in tandem (Fourie & Horak 1990, 1991; Fourie, Kok & Heyne 1996).

There are no tick species that infest either of these hosts to the exclusion of the other, but whereas goats are often the hosts of large numbers of immature ticks and fewer adults (Baker & Ducasse 1968; Bryson *et al*. 2002a; MacIvor & Horak 2003), cattle may harbour large numbers of both adult and immature ticks (Baker & Ducasse 1967; Horak 1982, 1999; Rechav 1982; Bryson *et al*. 2002b). There may, however, also be considerable proportional differences in the species composition of adult ticks on goats and cattle on the same farm (Fourie *et al*. 1996). After examining goats at five localities at which cattle were also present, Baker & Ducasse (1968) came to the conclusion that goats played an important role in maintaining tick infestations on stock farms in KwaZulu-Natal Province, and that they should be included in tick control programmes applied to cattle.

The opportunity to compare the species composition of ticks on goats and cattle examined in numerically equal small groups at the same time at several localities arose during a survey on the geographic distribution of ticks in the eastern region of the Eastern Cape Province, South Africa. The objective of the present communication is to highlight the role of goats as hosts of adult ticks of species that usually infest and transmit diseases to cattle.

MATERIALS AND METHODS

Within the five municipal districts that constitute the eastern region of the Eastern Cape Province, there are 1 057 communal dip-tanks at each of which there are 200 or more cattle registered, and 75 of these dip-tanks were selected for survey purposes. At each dip-tank five healthy adult goats, preferably with visible tick infestations, and five healthy, but preferably visibly tick-infested, year-old cattle were examined. Adult ticks were collected from the ears, bodies, bellies, feet, tails and peri-anal regions of these animals on the single occasion that each dip-tank was visited. The ticks were stored in 70 % ethyl alcohol in labelled vials for later identification and quantification under a stereoscopic microscope.

The length of the idiosoma of engorging female *R.* (*Boophilus*) *microplus* collected from the goats was measured and the number of maturing (also referred to as standard) females determined. The idiosomal length of a standard *R.* (*Boophilus*) *microplus* female is 4.5–8.0 mm in length and is an indication that she will fully engorge and detach within the next 24 h (Wharton & Utech 1970). The same procedure was not followed with the ticks collected from cattle because living engorging and engorged female *R.* (*Boophilus*) *microplus* were required for acaricide resistance tests. We have chosen to use the name *R.* (*Boophilus*) *microplus* as proposed by Murrell & Barker (2003) after Murrell, Campbell & Barker (2000) and Beati & Keirans (2001) had shown that the genus *Rhipicephalus* is paraphyletic with respect to the genus *Boophilus*. Many people, however, prefer to retain *Boophilus* as a generic name.

The collections of ticks from each goat or bovine were not intended to be exhaustive and consequently the numbers of ticks recovered from these animals cannot be compared. However, the presence or absence of particular tick species on the two host species as well as at the various dip-tanks can be compared. A Chi-square test was used to compare the proportion of dip-tanks at which goats were positive for each of the four tick species with the proportion of dip tanks at which cattle were positive for the same species.

It was possible to sample five goats and five cattle at 72 of the 75 selected dip-tanks and consequently the presence or absence of ticks on 360 goats could be compared with that on the same number of cattle. A Chi-square test was used to compare the proportion of positive goats to the proportion of positive cattle for each of the tick species, and Wilcoxon's signed rank test for matched pairs was used to compare the difference between the number of infested goats and the number of infested cattle at each dip-tank.

For comparative purposes the numbers of ticks collected from goats and cattle during previous surveys conducted at various localities in South Africa have been summarized and presented in tabular format.

RESULTS

Amblyomma hebraeum was present on goats at 25 and on cattle at 39 dip-tanks, and a total of 61 goats and 138 cattle were infested (Fig. 1). The proportion of dip-tanks at which goats were infested differed from the proportion of tanks at which infested cattle were present (Chi-square test, $P < 0.05$). The proportion of cattle infested with *A. hebraeum* was higher than the proportion of goats (Chi-square test, $P < 0.01$), and the median of the difference between the number of infested cattle and infested goats was greater than zero ($P < 0.01$).

Rhipicephalus (*Boophilus*) *microplus* was present on goats at 48 and on cattle at 69 dip-tanks, and a total of 113 goats and 242 cattle were infested (Fig. 1). The proportion of dip-tanks at which goats were infested differed from the proportion of tanks at which infested cattle were present (Chi-square test, $P <$

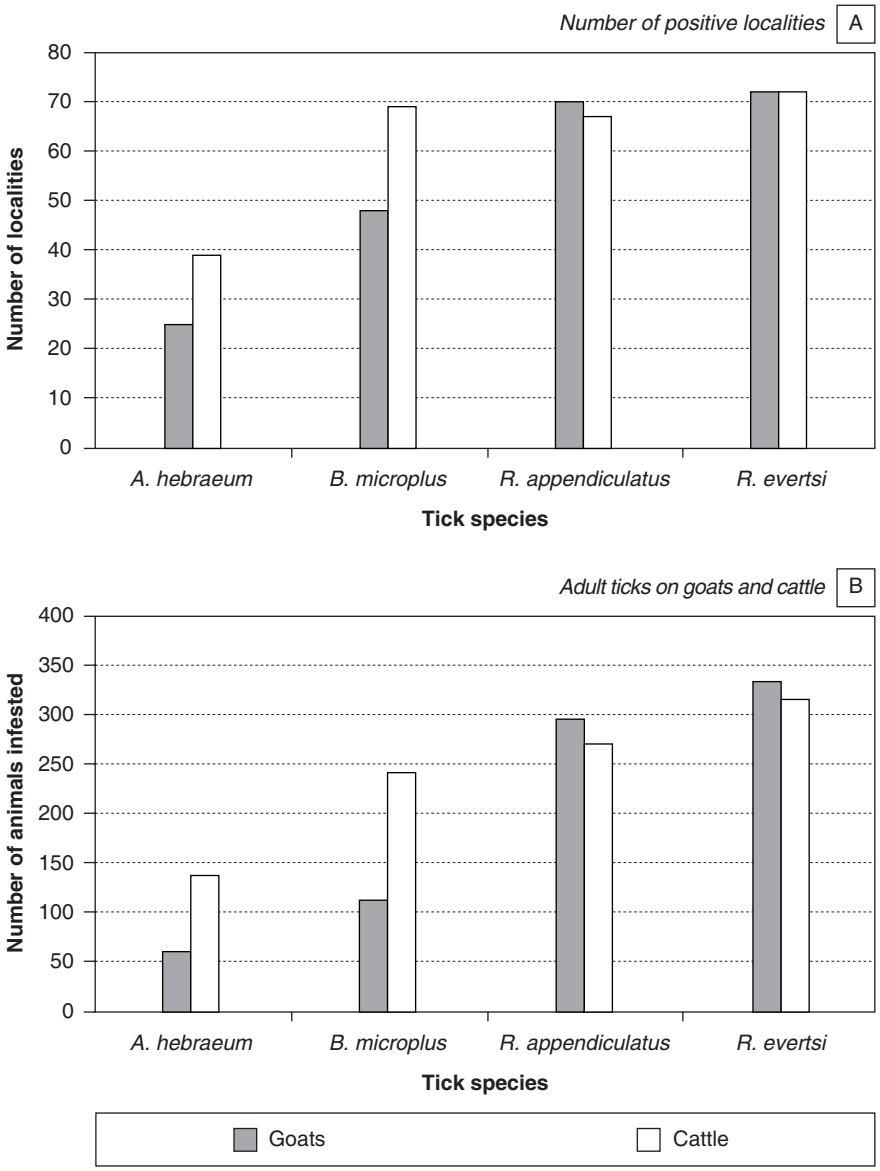

FIG. 1 The numbers of (A) dip-tanks at which *Amblyomma hebraeum*, *Rhipicephalus* (*Boophilus*) *microplus*, *Rhipicephalus appendiculatus* and *Rhipicephalus evertsi evertsi* were present on goats and cattle, and the total numbers of (B) goats and cattle on which these ticks were present at 72 dip-tanks in the eastern region of the Eastern Cape Province, South Africa

TABLE 1 Numbers of ticks collected in previous surveys from goats and cattle examined at the same localities in various provinces of South Africa

Province and Tick species	Total No. of adult ticks (total No. of collections)	
	Goats	**Cattle**
KwaZulu-Natal Province[1]	**Untreated**	**Untreated**
Amblyomma hebraeum	26 (10)	312 (20)
Rhipicephalus (Boophilus) microplus	266 (all stages) (9)	32 692 (all stages) (18)
Rhipicephalus appendiculatus	179 (39)	782 (70)
Rhipicephalus evertsi evertsi	184 (48)	662 (88)
Eastern Cape Province[2]	**Untreated, but ran with a treated herd**	**Untreated in previous 5 weeks**
Amblyomma hebraeum	16 (48)	1 092 (46)
Rhipicephalus appendiculatus	60 (48)	1 244 (46)
Rhipicephalus evertsi evertsi	3 (48)	74 (46)
North West Province[3]	**Untreated**	**Untreated in previous 7 days**
Amblyomma hebraeum	90 (123)	3 461 (141)
Rhipicephalus appendiculatus	38 (123)	1 387 (141)
Rhipicephalus evertsi evertsi	226 (123)	836 (141)
Mpumalanga Province[3]	**Untreated**	**Untreated in previous 7 days**
Amblyomma hebraeum	6 (30)	72 (36)
Rhipicephalus appendiculatus	32 (30)	38 (36)
Rhipicephalus evertsi evertsi	404 (30)	37 (36)
Free State Province[4]	**Untreated**	**Untreated**
Hyalomma marginatum rufipes	41 (750)	2 598 (397)
Hyalomma truncatum	72 (750)	270 (397)
Ixodes rubicundus	2 052 (750)	4 565 (397)
Rhipicephalus evertsi evertsi	3 (750)	197 (397)
Rhipicephalus warburtoni	3 782 (750)	562 (397)

1 Baker & Ducasse (1968)
2 Horak *et al.* (1991) and Horak (1999)
3 Bryson *et al.* (2002a, b)
4 Fourie & Horak (1990, 1991) and Fourie *et al.* (1996)

0.01). The proportion of infested cattle was higher than the proportion of infested goats (Chi-square test, $P < 0.01$), and the median of the difference between the number of infested cattle and infested goats was greater than zero ($P < 0.01$). One hundred and forty-eight female *R.* (*Boophilus*) *microplus* that had been collected from the goats were measured and 84 of these were 5 mm or more in length, implying that they would probably engorge and detach within the next 24 h.

Rhipicephalus appendiculatus was present on goats at 70 and on cattle at 67 dip-tanks, and a total of 296 goats and 271 cattle were infested. The proportion of dip-tanks at which goats were infested did not differ from the proportion of tanks at which cattle were infested (Fischer's exact probability test, $P = 0.44$). However, the proportion of cattle infested was lower than the proportion of goats (Chi-square test, $P < 0.05$), and the median of the difference between the number of infested cattle and infested goats was equal to zero ($P = 0.1$).

Rhipicephalus evertsi evertsi was present on goats and cattle at all 72 dip-tanks, and a total of 334 goats and 316 cattle were infested (Fig. 1). The proportion of infested cattle was lower than the proportion of infested goats (Chi-square test, $P < 0.05$), and the median of the difference between the number of infested cattle and of infested goats was less than zero ($P < 0.05$).

With the exception of Free State Province, in which certain species of ticks collected from goats and cattle differed considerably from those on goats and cattle examined in other provinces, the same three or four major species were collected at most localities (Table 1). Apart from *R. evertsi evertsi* on goats in Mpumalanga Province, and *Rhipicephalus warburtoni* on goats in Free State Province, cattle ex-

amined at the same localities as goats invariably harboured more adult ticks than did goats that were infested with the same species.

DISCUSSION

Horak, MacIvor, Petney & De Vos (1987) concluded that the larger the host species the greater the likelihood that it would harbour large numbers of adult *A. hebraeum*, and this was confirmed by the present findings. In ten collections made over a period of a year from a goat in Thornveld in KwaZulu-Natal, Baker & Ducasse (1967) recovered a total of 26 adult *A. hebraeum*. The total number collected from two calves sampled at the same times as the goat at the same locality, where no stock had been dipped in an acaricide for the previous 6 years, was 312 adult ticks (Table 1). Horak, Knight & Williams (1991) collected a total of 16 adult ticks from 48 adult Angora goats that were slaughtered in pairs at monthly intervals on a farm in Valley Bushveld in the Eastern Cape Province. Forty-six young cattle that were also slaughtered in pairs at monthly intervals at the same locality as the goats, were infested with a total of 1 092 adult *A. hebraeum*. Goats can, however, harbour larger numbers of adult ticks of this species and Rechav & De Jager (1991) recovered approximately 1 160 adult ticks in 220 collections made from goats over a period of 22 months in Limpopo Province. MacIvor & Horak (2003) collected totals of 387 and 214 adult ticks from 24 Angora and 24 of Boer goats respectively, that were each slaughtered in pairs at monthly intervals on a farm in Valley Bushveld in the Eastern Cape Province.

Rhipicephalus (*Boophilus*) *microplus* uses cattle as hosts and is usually only found on other animals provided infested cattle are present at the same locality. Baker & Ducasse (1967) recovered a total of 266 ticks in all stages of development in nine consecutive collections from a goat, while the total yield of nine collections from two calves at the same locality was 32 692 ticks (Table 1). Mason & Norval (1980) recorded 81 collections of *R.* (*Boophilus*) *microplus* from cattle and a single collection each from a goat and a horse during the National Tick Survey conducted in Zimbabwe. Horak, Sheppey, Knight & Beuthin (1986) recovered *R.* (*Boophilus*) *microplus* from a grey rhebok, *Pelea capreolus*, grazing with cattle outside the Bontebok National Park near Swellendam in the Western Cape Province, South Africa, but not one of 59 of these antelopes examined inside the park, where no cattle are permitted, was infested (Horak *et al*. 1986; Horak & Boomker 1998).

The recovery of *R.* (*Boophilus*) *microplus* from goats at so many localities in the present study can be ascribed to the high prevalence of infestation on cattle at the same dip-tanks (Fig. 1), and to the fact that questing *R.* (*Boophilus*) *microplus* larvae were collected from the vegetation at 62 of the 72 survey sites (Nyangiwe & Horak, unpublished data 2006). A more significant finding, however, is the large proportion of female ticks 5 mm or more in length collected from the goats. This is a good indication that the ticks were successfully completing their life cycles on the goats and could perhaps even do so in the absence of infested cattle to replenish their infestations. If this is so, a further adaptation to several wildlife species, particularly bushbuck, *Tragelaphus scriptus* and greater kudus, *Tragelaphus strepsiceros*, that share much of their habitat with goats in the Eastern Cape Province, and are excellent hosts of the closely related *R.* (*Boophilus*) *decoloratus* (Horak, Potgieter, Walker, De Vos & Boomker 1983; Horak, Boomker, Spickett & De Vos 1992), may be imminent.

Minimum temperature requirements for *R.* (*Boophilus*) *microplus* in Africa are approximately 4 °C lower than those required by the same species in South America, and in contrast to ticks in the latter region, African *R.* (*Boophilus*) *microplus* can withstand periods of low rainfall during the winter months (Estrada-Peña, Bouattour, Camicas, Guglielmone, Horak, Jongejan, Latif, Pegram & Walker 2006). Moreover, crossbreeding experiments between South African and Australian *R.* (*Boophilus*) *microplus* resulted in hybrid sterility (Spickett & Malan 1978), indicating additional mutations in South African *R.* (*Boophilus*) *microplus*. An adaptation by this tick to a new host species may thus not be an unrealistic expectation.

Domestic cattle and large herbivores such as greater kudus and male nyalas, *Tragelaphus angasii*, are hosts favoured by *R. appendiculatus* (Baker & Ducasse 1967; Horak 1982; Horak *et al.* 1992; Horak, Boomker & Flamand 1995). Horak *et al.* (1991) collected a total of only 60 adult ticks from 48 adult Angora goats, while 46 young cattle on the same farm harboured a total of 1 244 adult *R. appendiculatus* (Table 1). Twenty-five greater kudus examined on the farm and on an adjacent nature reserve harboured a total of 604 adult ticks (Horak *et al.* 1992). Although the actual numbers of ticks collected from goats and from cattle in the present study cannot be compared, 25 more goats at three more localities than cattle were infested with adult ticks.

Rhipicephalus evertsi evertsi has the most widespread distribution of all ticks belonging to the genus *Rhipicephalus* in Africa, and also has one of the largest host ranges (Walker *et al*. 2000). The preferred hosts of all its parasitic life stages are domestic and wild equids, but large numbers may infest cattle, goats and sheep (Norval 1981; Walker *et al*. 2000). Baker & Ducasse (1968) collected more adult ticks from untreated cattle than from goats at five localities in KwaZulu-Natal Province, but the converse was true for goats in Mpumalanga Province (Bryson *et al.* 2002a; Table 1). In the present study ticks were collected from both goats and cattle at all 72 survey localities, but a total of 334 goats compared to 316 cattle were infested with adult ticks (Fig. 1).

CONCLUSIONS

The results of this study indicate that goats are good hosts of most of the economically important ticks that infest cattle, and that *R.* (*Boophilus*) *microplus*, which has previously been considered a cattle tick, may be in the process of adapting to goats. In the light of these findings it is imperative to include goats in any tick control programme applied to sympatric cattle.

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