

PARASITES OF DOMESTIC AND WILD ANIMALS IN SOUTH AFRICA. XXV. IXODID TICKS ON SHEEP IN THE NORTH-EASTERN ORANGE FREE STATE AND IN THE EASTERN CAPE PROVINCE

I. G. HORAK⁽¹⁾, E. J. WILLIAMS⁽²⁾ and P. C. VAN SCHALKWYK⁽³⁾

ABSTRACT

HORAK, I. G., WILLIAMS, E. J. & VAN SCHALKWYK, P. C., 1991. Parasites of domestic and wild animals in South Africa. XXV. Ixodid ticks on sheep in the north-eastern Orange Free State and in the eastern Cape Province. *Onderstepoort Journal of Veterinary Research*, 58, 115–123 (1991)

The tick burdens of 115 Merino sheep, slaughtered over a period of 15 consecutive months on a farm in the north-eastern Orange Free State, were determined. A total of 7 ixodid and 1 argasid tick species were recovered and the seasonal abundances of *Boophilus decoloratus*, *Hyalomma marginatum rufipes*, *Margaropus winthemi* and *Rhipicephalus evertsi evertsi* were determined.

One hundred and forty-nine Merino sheep were slaughtered over periods varying from 10 to 25 months on 3 farms in Eastern Province Thornveld in the eastern Cape Province and their tick burdens determined. Fourteen ixodid tick species were recovered from these animals and the seasonal abundances of *Amblyomma marmoratum*, *B. decoloratus*, *Haemaphysalis silacea*, *R. evertsi evertsi* and *Rhipicephalus nitens* were ascertained.

On a farm in Valley Bushveld in the eastern Cape Province, 2 Dorper sheep were slaughtered each month for a period of 24 consecutive months. These 48 sheep harboured 10 ixodid tick species and the seasonal abundances of *A. marmoratum*, *H. silacea*, *Rhipicephalus appendiculatus* and *Rhipicephalus glabroscutatum* were determined.

A total of 17 ixodid tick species, of which 12 had reached the adult stage, were recovered from the sheep on the 5 farms.

INTRODUCTION

Many ixodid tick species have already been recovered from sheep. Theiler (1962) records a total of 46 species as having been recovered in the adult stage from sheep in Africa south of the Sahara, while Yeoman & Walker (1967) recorded the adults of 14 species from sheep in Tanzania and Walker (1974) those of 21 species from sheep in Kenya. Six species of ixodids are listed by Fourie, Horak & Marais (1988) as important parasites of sheep in South Africa. These are *Amblyomma hebraeum*, *Hyalomma* spp., *Ixodes rubicundus*, *Rhipicephalus evertsi evertsi* and *Rhipicephalus glabroscutatum*.

In this country, the total tick burdens of 24 Dorper sheep on a farm in Valley Bushveld in the eastern Cape Province have been determined and the adults of 4 species recovered (Horak & Knight, 1986). The seasonal abundance of adult *I. rubicundus* has been recorded on sheep in the Karoo (Stampa, 1959) and in the south-western Orange Free State where, in addition, that of *Hyalomma marginatum rufipes* and a *Rhipicephalus* sp. (near *R. punctatus*), has been ascertained (Fourie *et al.*, 1988).

The present paper describes the burdens and seasonal abundance of ixodid ticks on Merino sheep in the north-eastern Orange Free State and in Eastern Province Thornveld and on Dorper sheep in Valley Bushveld in the eastern Cape Province. The findings for the Dorpers are an amplification of those recorded by Horak & Knight (1986) plus those from another 24 of these sheep.

MATERIALS AND METHODS

Survey animals

The sheep slaughtered in the 5 surveys reported here were all also processed for the recovery of helminths. The various periods of exposure to infestation prior to slaughter were dictated by the data de-

sired from the helminth surveys. The shortest period of exposure was approximately 1 month, which we consider more than adequate to acquire representative tick burdens. None of the sheep were treated with an acaricide for at least 12 weeks prior to slaughter.

Parasite recovery

After slaughter half the skin of the head and of the body (excluding the heavily woolled portions) of each sheep, plus 1 front and 1 back leg, were processed for tick recovery as described by Horak, Meltzer & De Vos (1982). In addition a 100 × 100 mm piece of skin, with wool attached, was excised from just behind the shoulder on 1 side of each sheep. This piece of skin was examined *in toto* under a stereoscopic microscope and the ticks collected, identified, counted and added to the burdens which had been calculated from the processed material, as described by Horak, Potgieter, Walker, De Vos & Boomker (1983).

Many of the tick larvae collected in the surveys had already died prior to the sheep being processed for tick recovery. These larvae were nevertheless counted, identified and considered part of the total tick burden of each sheep.

SURVEYS ON INDIVIDUAL FARMS

“Tweespruit”

The farm “Tweespruit” (27° 25' S, 29° 32' E) is situated 35 km east of Vrede in the north-eastern Orange Free State. The vegetation is classified as Themeda Veld to Cymbopogon/Themeda Veld Transition (Acocks, 1975). This is a summer rainfall region with regular frost during winter. The Merino sheep grazed the natural vegetation and during droughts were fed concentrates and lucerne hay. There were also approximately 100 cattle and 12 horses on the farm.

Except in October 1983, when no older lambs were slaughtered, 3 to 6 lambs which had run on the farm “Tweespruit” since birth were slaughtered each month from November 1982 to February 1984. In addition 1 to 3, 2 to 5-month old lambs, that had been raised under worm-free conditions at a laboratory and then exposed to infestation with the

⁽¹⁾ Department of Parasitology, Faculty of Veterinary Science, University of Pretoria, Onderstepoort 0110, Republic of South Africa

⁽²⁾ Tick Research Unit, Rhodes University, Grahamstown 6140

⁽³⁾ SmithKline Animal Health, P.O. Box 6466, Birchleigh 1621

Received 4 March 1991—Editor

TABLE 1 Total numbers of ticks recovered from 115 Merino sheep on the farm "Tweespruit" in the north-eastern Orange Free State from November 1982 to February 1984

Species	Total numbers recovered					Number of sheep infested
	Larvae	Nymphs	Males	Females	Total	
<i>Amblyomma hebraeum</i>	1	1	0	0	2	2
<i>Boophilus decoloratus</i>	1 595	153	88	60 (19)	1 896	109
<i>Haemaphysalis</i> sp.	2	0	0	0	2	1
<i>Hyalomma marginatum rufipes</i>	3	0	5	2	10	9
<i>Margaropus winthemi</i>	78	0	0	0	78	16
<i>Rhipicephalus evertsi evertsi</i>	8 761	584	818	300 (85)	10 463	115
<i>Rhipicephalus</i> sp.	1	1	0	0	2	2
<i>Otobius megnini</i>	2	3	0	0	5	4
Total	10 443	742	911	362 (104)	12 458	

() = Number of maturing female ticks, i.e. idiosoma of *B. decoloratus* > 4,0 mm; *R. evertsi evertsi* > 6,0 mm in length

flock on "Tweespruit" for a month, were slaughtered each month from December 1982 to February 1984.

Seven species of ixodid ticks and 1 argasid were collected (Table 1). *Rhipicephalus evertsi evertsi* was the most numerous and all sheep were infested. Most sheep were also infested with *Boophilus decoloratus*, which was the next most abundant tick.

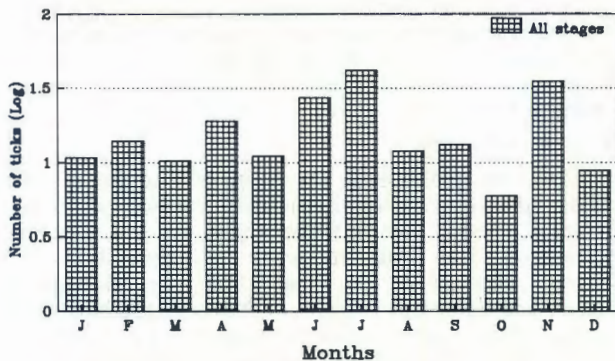


FIG. 1 The mean monthly mean abundance of *Boophilus decoloratus* on Merino sheep on the farm "Tweespruit"

Peak mean monthly mean burdens of *B. decoloratus* were present during June, July and November (Fig. 1). The largest mean monthly mean numbers of immature *R. evertsi evertsi* were recovered during March and June and of adults from March to May with a minor peak in October and November (Fig. 2).

Larvae of *M. winthemi* were present from June to September 1983. A few adult *Hyalomma marginatum rufipes* were recovered from March to May 1983.

"Reed Valley", "Sidbury" and "Grasmere"

The farms "Reed Valey" (33° 33' S, 26° 02' E) 14 km south-east of Paterson, "Sidbury" (33° 25' S, 26° 11' E) at Sidbury and "Grasmere" (33° 31' S, 25° 53' E) 12 km south-west of Paterson are all situated in a vegetation zone classified as Eastern Province Thornveld (Acocks, 1975) in the eastern Cape Province. Mean maximum air temperatures range between approximately 20 °C during winter and 30 °C during summer and mean minima between approximately 8 °C during winter and 18 °C during summer. Mean annual rainfall in this region is approximately 500 mm and is non-seasonal, with the major portion falling during spring and sum-

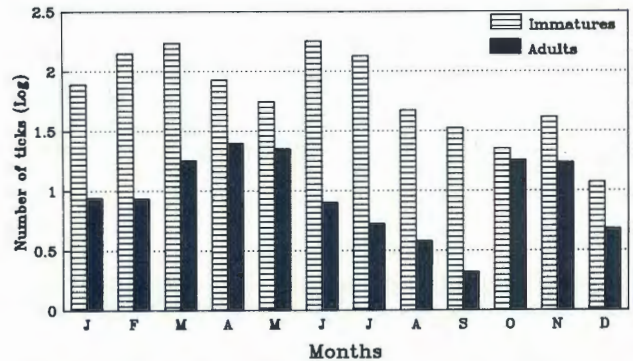


FIG. 2 The mean monthly mean abundance of *Rhipicephalus evertsi evertsi* on Merino sheep on the farm "Tweespruit"

mer. In addition to Merino sheep the farms "Reed Valley" and "Sidbury" each ran a herd of dairy cattle while the farm "Grasmere" also ran a herd of beef cattle and a flock of Angora goats.

On the farms "Reed Valley" and "Sidbury", 4 and 3, 10-14 month-old Merino lambs respectively, originating from neighbouring farms, were exposed to infestation at monthly intervals with resident flocks of Merino sheep for a month before slaughter. The survey ran for 13 consecutive months (March 1983 to March 1984) on "Reed Valley" and 25 months (March 1986 to March 1988) on "Sidbury". On the farm "Grasmere" 2 autumn-born Merino lambs, running with a flock of ewes and lambs, were slaughtered each month from 1 day of age until they were 9 months old from May 1986 to February 1987.

The total numbers of *B. decoloratus* recovered from the sheep on "Reed Valley" and "Sidbury" have been combined and mean monthly mean burdens calculated and illustrated in a single figure (Fig. 3). The burdens of *R. evertsi evertsi* of the same sheep have been treated in a similar fashion (Fig. 4).

Peak burdens of *B. decoloratus* were present during July and November. The largest numbers of immature *R. evertsi evertsi* were recovered during January and October and of adults during November.

Twelve species of ixodid ticks, of which *R. evertsi evertsi* was the most numerous and prevalent, were present on "Reed Valley" (Table 2).

The largest numbers of larvae of *A. marmoreum* were present from March to May and nymphs during November.

TABLE 2 Total numbers of ixodid ticks recovered from 52 Merino sheep on the farm "Reed Valley" in the eastern Cape Province from March 1983 to March 1984

Species	Total numbers recovered					Number of sheep infested
	Larvae	Nymphs	Males	Females	Total	
<i>Amblyomma hebraeum</i>	56	8	0	0	64	17
<i>Amblyomma marmoreum</i>	374	10	0	0	384	20
<i>Boophilus decoloratus</i>	414	8	8	14 (4)	444	35
<i>Haemaphysalis silacea</i>	12	0	8	0	20	9
<i>Hyalomma marginatum rufipes</i>	30	0	0	0	30	4
<i>Hyalomma truncatum</i>	0	0	2	0	2	1
<i>Ixodes pilosus</i>	18	4	0	2	24	10
<i>Rhipicephalus appendiculatus</i>	0	2	0	0	2	1
<i>Rhipicephalus evertsi evertsi</i>	2 324	60	126	42 (6)	2 552	50
<i>Rhipicephalus glabroscutatum</i>	8	2	0	0	10	4
<i>Rhipicephalus nitens</i>	42	6	4	6 (2)	58	10
<i>Rhipicephalus simus</i>	0	0	10	4	14	5
Total	3 278	100	158	68 (12)	3 604	

() = Number of maturing female ticks, i.e. the idiosoma of *B. decoloratus* > 4,0 mm; *R. evertsi evertsi* > 6,0 mm; *R. nitens* > 5,0 mm

TABLE 3 Total numbers of ixodid ticks recovered from 75 Merino sheep on the farm "Sidbury" in the eastern Cape Province from March 1986 to March 1988

Species	Total numbers recovered					Number of sheep infested
	Larvae	Nymphs	Males	Females	Total	
<i>Amblyomma hebraeum</i>	848	30	34	4(2)	916	32
<i>Amblyomma marmoreum</i>	366	8	0	0	374	38
<i>Boophilus decoloratus</i>	4 722	112	28	44(22)	4 906	58
<i>Haemaphysalis leachi</i>	6	0	0	0	6	2
<i>Haemaphysalis silacea</i>	146	88	8	12(4)	254	12
<i>Hyalomma truncatum</i>	0	0	2	0	2	1
<i>Ixodes pilosus</i>	54	30	0	0	84	10
<i>Rhipicephalus appendiculatus</i>	0	38	0	2	40	15
<i>Rhipicephalus evertsi evertsi</i>	57 012	1 564	542	292(70)	59 410	75
<i>Rhipicephalus glabroscutatum</i>	28	0	0	0	28	3
<i>Rhipicephalus nitens</i>	35 616	3 566	494	370(52)	40 046	74
<i>Rhipicephalus simus</i>	0	0	2	4	6	1
Total	98 768	5 466	1 110	728(150)	106 072	

() = Number of maturing female ticks, i.e. idiosoma of *A. hebraeum* > 9,0 mm; *B. decoloratus* > 4,0 mm; *H. silacea* > 5,0 mm; *R. evertsi evertsi* > 6,0 mm; *R. nitens* > 5,0 mm

Twelve tick species, of which *R. evertsi evertsi* and *R. nitens* were the most numerous and prevalent, were recovered from the sheep on "Sidbury" (Table 3, Fig. 5).

The larvae of *R. nitens* peaked during autumn, and the nymphs during late winter and spring. The largest numbers of adults were present during mid-summer.

The lambs on "Grasmere" were infested with 6 tick species, of which *R. evertsi evertsi* was the most numerous and, together with *Haemaphysalis silacea*, the most prevalent (Table 4). Because the lambs

were slaughtered over a period shorter than a year no definite conclusions on the seasonal abundance of the ticks can be drawn. However, the larvae of *H. silacea* were present from mid-summer to spring, the nymphs from winter to mid-summer and the adults in mid-winter and mid-summer.

"Bucklands"

The farm "Bucklands" (33° 06' S, 26° 41' E) is situated 28 km north-east of Grahamstown in the eastern Cape Province in a vegetation zone classified

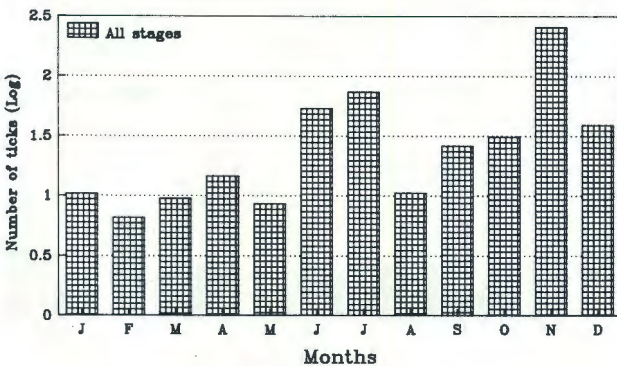


FIG. 3 The combined mean monthly abundance of *Boophilus decoloratus* on Merino sheep on the farms "Reed Valley" and "Sidbury"

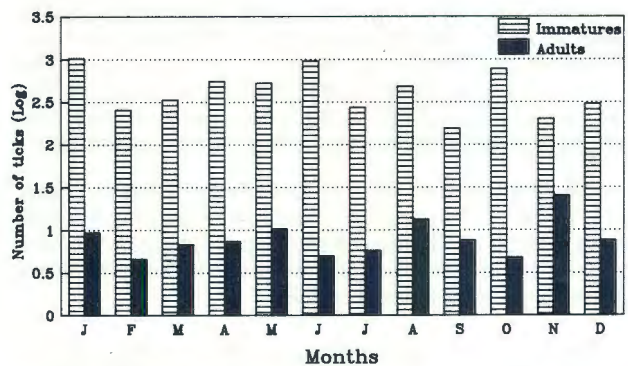


FIG. 4 The combined mean monthly mean abundance of *Rhipicephalus evertsi evertsi* on Merino sheep on the farms "Reed Valley" and "Sidbury"

TABLE 4 Total numbers of ixodid ticks recovered from 22 Merino lambs on the farm "Grasmere" in the eastern Cape Province from May 1986 to February 1987

Species	Total numbers recovered					Number of sheep infested
	Larvae	Nymphs	Males	Females	Total	
<i>Amblyomma hebraeum</i>	8	20	2	2	32	6
<i>Boophilus decoloratus</i>	8	0	0	0	8	2
<i>Haemaphysalis silacea</i>	288	181	20	10(2)	499	22
<i>Ixodes pilosus</i>	133	42	6	2	183	14
<i>Rhipicephalus evertsi evertsi</i>	3 613	96	44	54(12)	3 807	22
<i>Rhipicephalus</i> sp.	10	0	0	0	10	3
Total	4 060	339	72	68(14)	4 539	

() = Number of maturing female ticks, i.e. idiosoma of *H. silacea* > 5,0 mm; *R. evertsi evertsi* > 6,0 mm

TABLE 5 The total numbers of ticks recovered from 48 Dorper sheep on the farm "Bucklands" in the eastern Cape Province from February 1985 to January 1987

Species	Total numbers recovered					Number of sheep infested
	Larvae	Nymphs	Males	Females	Total	
<i>Amblyomma hebraeum</i>	120	90	10	8(4)	228	22
<i>Amblyomma marmoreum</i>	392	12	0	0	404	23
<i>Boophilus decoloratus</i>	6	0	0	0	6	2
<i>Haemaphysalis silacea</i>	2 030	700	40	10(2)	2 780	43
<i>Hyalomma marginatum rufipes</i>	0	0	0	2	2	1
<i>Rhipicephalus appendiculatus</i>	4 934	290	2	4(2)	5 230	32
<i>Rhipicephalus evertsi evertsi</i>	98	46	4	8(2)	156	21
<i>Rhipicephalus glabroscutatum</i>	3 262	154	106	62(18)	3 584	45
<i>Rhipicephalus</i> sp. (Near <i>R. oculatus</i>)	0	0	2	0	2	1
<i>Rhipicephalus simus</i>	0	0	2	2	4	1
Total	10 842	1 292	166	96(28)	12 396	

() = Number of maturing female ticks, i.e. idiosoma of *A. hebraeum* > 9,0 mm; *H. silacea* > 5,0 mm; *R. appendiculatus* > 5,0 mm; *R. evertsi evertsi* > 6,0 mm; *R. glabroscutatum* > 4,5 mm

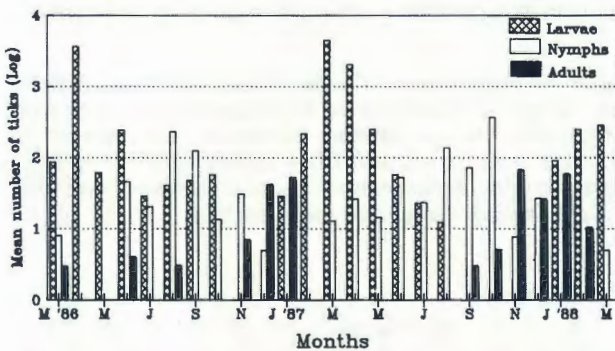


FIG. 5 The seasonal abundance of *Rhipicephalus nitens* on Merino sheep on the farm "Sidbury"

as Valley Bushveld (Acocks, 1975). Rainfall is non-seasonal and the long-term mean annual total is 484 mm of which slightly more than 300 mm falls from October to March. At the time of the survey the farm grazed approximately 300 Dorper sheep, 4 000 angora goats and 185 cattle plus approximately 300 free-ranging kudu and numerous smaller antelope.

At "Bucklands" 2, 8-12 month-old Dorper (Dorset Horn x Blackhead Persian) lambs, which ran with a flock of Dorper sheep, were slaughtered each month for a period of 24 consecutive months from February 1985 to January 1987.

Rhipicephalus appendiculatus, followed by *R. glabroscutatum* and *H. silacea* were the most abundant ticks. *R. glabroscutatum* was also the most prevalent (Table 5, Fig. 6-8)

Peak numbers of immature *H. silacea* were present during May and July 1985 and April and May 1986, while few adults were recovered. The largest numbers of *R. appendiculatus* larvae were collected from March or May to July and nymphs from April or May to September. Only 6 adults were recovered. Immature *R. glabroscutatum* were recovered in peak numbers from April to September 1985 and during April and May 1986. Adults preferred the months September or October to February or March.

The largest numbers of larvae of *A. marmoreum* were generally present from February to May and nymphs during September and October.

General

A total of 17 ixodid tick species were recovered from all the sheep, irrespective of locality. *R. evertsi*

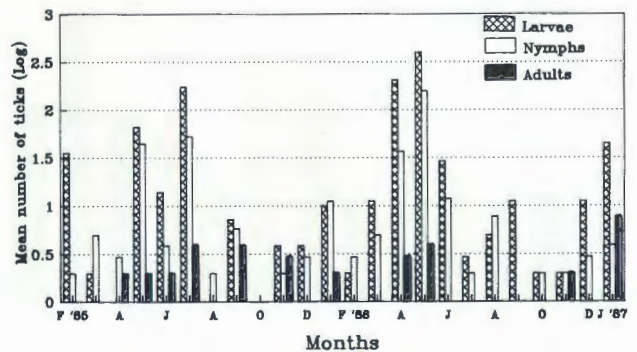


FIG. 6 The seasonal abundance of *Haemaphysalis silacea* on Dorper sheep on the farm "Bucklands"

TABLE 6 Total numbers of ixodid ticks recovered from 312 sheep examined in the north-eastern Orange Free State and the eastern Cape Province

Species	Total numbers recovered				
	Larvae	Nymphs	Males	Females	Total
<i>Amblyomma hebraeum</i>	1 033	149	46	14(2)	1 242
<i>Amblyomma marmoreum</i>	1 132	30	0	0	1 162
<i>Boophilus decoloratus</i>	6 745	273	124	118(45)	7 260
<i>Haemaphysalis leachi</i>	6	0	0	0	6
<i>Haemaphysalis silacea</i>	2 476	969	76	32(8)	3 553
<i>Haemaphysalis</i> sp.	2	0	0	0	2
<i>Hyalomma marginatum rufipes</i>	33	0	5	4	42
<i>Hyalomma truncatum</i>	0	0	4	0	4
<i>Ixodes pilosus</i>	205	76	6	4	291
<i>Margaropus winthemi</i>	78	0	0	0	78
<i>Rhipicephalus appendiculatus</i>	4 934	330	2	6(2)	5 272
<i>Rhipicephalus evertsi evertsi</i>	71 808	2 350	1 534	696(175)	76 388
<i>Rhipicephalus glabroscutatum</i>	3 298	156	106	62(18)	3 622
<i>Rhipicephalus nitens</i>	35 658	3 572	498	376(54)	40 104
<i>Rhipicephalus simus</i>	0	0	14	10	24
<i>Rhipicephalus</i> sp. (near <i>R. oculatus</i>)	0	0	2	0	2
<i>Rhipicephalus</i> sp.	11	1	0	0	12
Total	127 389	7 936	2 417	1 322(304)	139 064

() = Number of maturing female ticks, i.e. idiosoma of *A. hebraeum* > 9,0 mm; *B. decoloratus* > 4,0 mm; *H. silacea* > 5,0 mm; *H. marginatum rufipes* > 7,5 mm; *I. pilosus* > 5,0 mm; *R. appendiculatus* > 5,0 mm; *R. evertsi evertsi* > 6,0 mm; *R. glabroscutatum* > 4,5 mm; *R. nitens* > 5,0 mm; *R. simus* > 6,0 mm

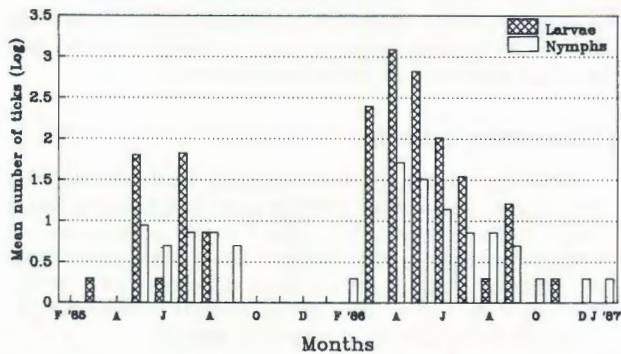


FIG. 7 The seasonal abundance of *Rhipicephalus appendiculatus* on Dorper sheep on the farm "Bucklands"

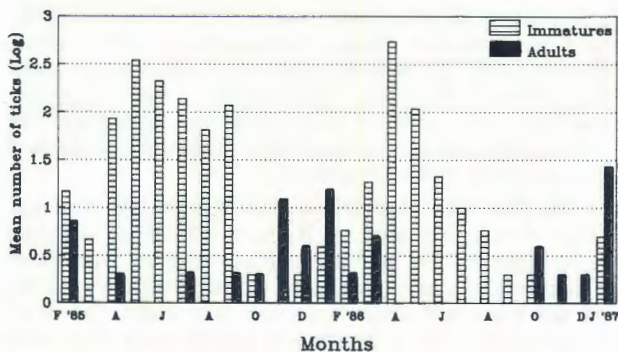


FIG. 8 The seasonal abundance of *Rhipicephalus glabroscutatum* on Dorper sheep on the farm "Bucklands"

evertsi was the most abundant tick followed by *R. nitens* and *B. decoloratus* (Table 6). The adults of 12 of these species were present on the sheep.

DISCUSSION

General observations

Probably one of the most notable findings of these surveys was that, although numerous larvae of many tick species were recovered from the sheep, many of

them had already died before the animals were processed for tick recovery. The reason for the death of the larvae is possibly either suffocation in the wool-fat or the residual effects of acaricide which had been applied several months previously.

The dead larvae that remained on the sheep contributed to the imbalance between the larval, nymphal and adult numbers. The total numbers of ticks, irrespective of species, recovered in each stage of development were 127 389 larvae, 7 936 nymphs and 3 739 adults (Table 6), a ratio of 34,1:2,1:1,0. These proportions indicate that sheep are not good hosts of nymphs or adults. The nymph to adult ratio indicates that, with the exception of a few species, sheep are as good hosts of adult ticks as they are of nymphs. In addition 304 ticks of the total female population of 1 322 had reached a size which indicated that they were engorging successfully and would probably detach within the next 24 to 48 h. This high proportion of engorging female ticks implies that virtually all female ticks on sheep will successfully engorge and detach.

Amblyomma hebraeum

The larvae and nymphs of this tick utilize a large variety of small and large mammals and some ground-nesting birds as hosts (Theiler, 1962; Norval, 1983; Horak, MacIvor, Petney & De Vos, 1987). It is thus not surprising that they should also be recovered from sheep. The adults prefer large hosts such as cattle, kudu, eland, buffalo and giraffe (Horak, Potgieter, Walker, De Vos & Boomker, 1983; Horak, MacIvor, Petney & De Vos, 1987) and the small numbers recovered from the sheep reflect this preference.

The Valley Bushveld region of the eastern Cape Province is a particularly good habitat for *A. hebraeum* (Knight & Rechav, 1978; Rechav, 1982; MacIvor & Horak, 1984; Horak & Knight, 1986). The relatively small numbers recovered from the Dorper sheep on the farm "Bucklands" are the survivors of prolonged, regular acaricidal treatment

aimed specifically at this tick (Horak & Knight, 1986; Petney & Horak, 1987). The north-eastern Orange Free State is not a recognized habitat of *A. hebraeum* (Howell, Walker & Nevill, 1978), and the 2 ticks recovered from the sheep on "Tweespruit" had possibly been transported there in a previous stage of development on either domestic stock or on migratory birds.

No pattern of seasonal abundance was evident on the sheep examined in the eastern Cape Province. All stages were present in small numbers throughout the year.

In South Africa *A. hebraeum* is the most important vector of *Cowdria ruminantium*, the cause of heartwater in sheep, goats and cattle (Bezuidenhout, 1987). Thus sheep may act not only as a source of ticks but also of *C. ruminantium* for goats or cattle, and *vice versa*, on farms where all 3 are grazed.

Amblyomma marmoreum

All stages of this tick, commonly known as the South African tortoise tick, feed on tortoises (Norval, 1975; Dower, Petney & Horak, 1988). The immature stages also have a wide range of alternative hosts (Theiler, 1962; Norval, 1975; Horak, MacIvor, Petney & De Vos, 1987), hence their recovery from sheep is not unexpected.

Compared with *A. hebraeum*, relatively large numbers of larvae of *A. marmoreum* were recovered from the sheep on "Reed Valley" and "Bucklands", indicating that the acaricidal treatment regimes practised on these farms for the control of the former tick did not affect *A. marmoreum* to the same extent. This is not surprising as its adults are found almost exclusively on tortoises (Theiler, 1962; Norval, 1975; Petney, Horak & Rechav, 1987). It also implies that these farms, and "Sidbury", are suitable habitats for tortoises, particularly the leopard or mountain tortoise, *Geochelone pardalis*, which seems to be a preferred host of the adults (Theiler, 1962; Norval, 1975; Dower *et al.*, 1988).

On "Reed Valley" and "Bucklands" the larvae were present mainly during late summer and autumn and the nymphs during spring, a seasonal pattern previously observed by Norval (1975) and Horak & Williams (1986). On "Sidbury" the larvae were recovered throughout the year apart from December and January.

Boophilus decoloratus

Large numbers of this 1-host tick are frequently recovered from its preferred wild hosts, namely giraffe, eland, kudu, bushbuck and Burchell's zebras, on which the ratio of larvae to nymphs to adults is approximately 4:2:1 (Horak, Potgieter, Walker, De Vos & Boomker, 1983; Horak, De Vos & De Klerk, 1984). The survey sheep harboured relatively small burdens, but this could have been due to acaricidal treatment of other stock on the farms suppressing the overall populations. The ratio of 27,9 larvae to 1,1 nymph to 1 adult on sheep (Table 6) is closest to that on blue wildebeest (8,9:1,7:1), which are considered to be naturally resistant to infestation with *B. decoloratus* (Horak, De Vos & Brown, 1983). On these antelope the marked decrease in numbers between the larval and nymphal stage is probably due to an immune

response of the host similar to that observed in cattle resistant to *Boophilus microplus* (Wagland, 1979). On sheep it is probably mainly due to an accumulation of dead larvae suffocated by wool-fat or killed by the residual effects of an acaricide and trapped in the fleece. Once the larvae reach the nymphal stage on sheep further development to adults appears to be unhindered as does the engorgement of the females.

The seasonal abundance of *B. decoloratus* on the sheep, with peaks during July and November, resembles that on cattle in the eastern Cape Province (Rechav, 1982) and blue wildebeest and Burchell's zebras in the north-eastern Transvaal (Horak, De Vos & Brown, 1983; Horak *et al.*, 1984). However, the peaks on the latter 3 host species were all approximately 1 month earlier than those on the sheep. The spring or early summer peak (September–November) is probably due to the synchronous hatching of eggs that had accumulated during the winter months (Robertson, 1981).

B. decoloratus is a vector of *Babesia bigemina*, the cause of African redwater or babesiosis in cattle (Potgieter, 1977). The infection passes transovarially in the ticks and is not lost even if the tick should feed on a refractory host (Gray & Potgieter, 1981). Consequently sheep should be considered as reservoirs of infected ticks on any farm on which there has been an outbreak of babesiosis in cattle.

Haemaphysalis leachi

Small numbers, of larvae only, were recovered. These are accidental infestations originating from adult ticks, carried by either wild carnivores or domestic dogs on the farms. The immature stages are usually found on rodents (Hoogstraal, 1956; Norval, 1984), and the sheep probably became infested by lying down on questing larvae.

Haemaphysalis silacea

This tick is associated with well-wooded ravines and river valleys in the eastern Cape Province and, to a lesser extent, Natal (Howell *et al.*, 1978). Thus considerably greater burdens were recovered from the Dorper sheep on "Bucklands", with its dense bush and tree cover, than from the sheep on the other farms in the eastern Cape Province which had a more open type of thornveld.

The surveys conducted by Knight & Rechav (1978) on kudu, and by Rechav (1982) on Angora goats and cattle in Valley Bushveld on and near "Bucklands", also indicated considerable variation in the seasonal abundance of this tick. The prolonged presence of larvae and nymphs and the summer and winter peaks of adult abundance (Rechav, 1982; "Grasmere") indicate that more than 1 life cycle can be completed annually.

Hyalomma spp.

The 3 ticks of this genus found in South Africa all prefer the drier regions of the country (Howell *et al.*, 1978). Hence quite large numbers were recovered by Fourie *et al.* (1988) from Merino sheep in the semi-arid south-western Orange Free State compared with the small numbers on the sheep in the present surveys, all of which were conducted on farms with moister climates. Fourie *et al.* (1988) recorded peak burdens of adult *H. marginatum rufipes* on sheep

from November to April. The very few adult ticks of this species that we recovered were present from March to May.

The preferred hosts of the adult ticks are large animals such as cattle, eland and zebras (Hoogstraal 1956; Rechav, 1986; Horak, Knight & De Vos, 1986), on which they occur during the summer months. Scrub hares are the preferred hosts of the immature stages of all 3 *Hyalomma*s (Rechav, 1986; Horak & MacIvor, 1987), while ground-nesting birds may be infested with the 2 subspecies of *H. marginatum* (Horak & Williams, 1986; Horak & Knight, 1986). The 33 larvae of *H. marginatum rufipes* recovered from the sheep on the farms "Tweespruit" and "Reed Valley" must be considered accidental infestations.

Ixodes pilosus

This tick is found in sourveld regions, particularly in wooded ravines and vegetation bordering streams, along the coast from Port Shepstone in southern Natal to Cape Town in the south-western Cape Province (Howell *et al.*, 1978). The farms "Reed Valley", "Sidbury" and "Grasmere" are situated within 40 km of the southern coast-line and hence probably lie within the distribution range of *I. pilosus*. The small numbers recovered indicate either that sheep are not good hosts, or that the farms lie at the limits of the tick's distribution. Horak, Sheppey, Knight & Beuthin (1986), Horak, Jacot Guillarmod, Moolman & De Vos (1987) and Horak, Keep, Spickett & Boomker (1989) consider grey rhebuck, caracal and bushbuck to be some of the preferred hosts of *I. pilosus*.

Margaropus winthemi

This 1-host tick is recorded almost exclusively in the Republic of South Africa and Lesotho, where it prefers higher-lying regions with cold winters (Howell *et al.*, 1978). Its preferred hosts are equids, among them Cape mountain zebras, on which very large numbers may be encountered during winter (Horak, Knight & De Vos, 1986). Sheep are obviously not good hosts as development does not proceed beyond the larval stage. Even though very few larvae were recovered from the sheep, these were present from June to September (winter to early spring), confirming the preference of this tick for the colder months. The infestation on "Tweespruit" was probably maintained by horses and cattle.

Rhipicephalus appendiculatus

Howell *et al.* (1978), making use of Theiler's (1962) distribution data, show *R. appendiculatus*, as occurring in the south-western Cape Province. Horak, Sheppey, Knight & Beuthin (1986) suggest that this tick does not occur in this region and that its southern distribution probably does not extend west much past 25° E. The findings on "Bucklands", "Reed Valley" and "Sidbury" confirm this supposition. At "Bucklands" (26° 41' E) large numbers of *R. appendiculatus* were recovered, whereas at "Sidbury" (26° 11' E) and "Reed Valley" (26° 02' E), *R. appendiculatus* had virtually disappeared and had been replaced by *R. nitens*. This finding indicates that the distribution of *R. appendiculatus* probably does not extend west along the southern coast beyond 26° E.

The seasonal abundance of the larvae and nymphs on the Dorper sheep at "Bucklands" is similar to that observed a few years earlier by Rechav (1982)

on Angora goats and cattle on the same farm. The small number of adults recovered from the sheep indicate that they are not good hosts of this stage of development. Angora goats, and particularly cattle, examined on "Bucklands" at the same time as the Dorper sheep, harboured considerably greater numbers of adults (Horak & Knight, 1986).

Rhipicephalus evertsi evertsi

This 2-host tick has a widespread distribution covering most of the eastern as well as the south-western portion of the country (Howell *et al.*, 1978). It was recovered from sheep on each of the 5 farms surveyed and, with the exception of "Bucklands", was the most abundant and prevalent tick.

The preferred hosts of all stages of development are equids (Hoogstraal, 1956; Norval, 1981). Horak *et al.*, (1984) and Horak, Knight & De Vos (1986) recovered large numbers from Burchell's and Cape mountain zebras, on which the ratio of larvae to nymphs to adults was 7,9:4,0:1,0. On the sheep this ratio was 32,2:1,1:1,0 (Table 6). It is thus obvious that many larvae die on the sheep before moulting to nymphs. This is supported by the fact that a large proportion of the larvae were recovered from the legs and bodies of the sheep, whereas the preferred site of attachment on the definitive hosts is the ear canal, where moulting to the nymphal stage occurs (Howell *et al.*, 1978).

The life stage ratios on zebras indicate that 1 of 4 nymphs may eventually give rise to an adult on the same host species. Thus 3 of the 4 ticks either die or find another host during this process. The approximate parity between nymphs and adults on sheep indicates that a fairly large number of nymphs must have fed on other hosts (probably horses, cattle or hares) on the farms and then infested sheep in the adult stage. Sheep must be considered one of the preferred hosts of adult *R. evertsi evertsi* as several animals harboured more than 30 ticks. Although this tick is widely distributed the adults are rarely abundant except on equids, on which they occur in large numbers, and 30 must be considered a fairly heavy burden.

The engorging females of *R. evertsi evertsi* transmit a toxin that causes paralysis in sheep (Hamel & Gothe, 1978), commonly known as spring lamb paralysis. The occurrence and severity of this paralysis is dependent upon the number of engorging female ticks simultaneously reaching a mass of 15–21 mg in relation to the mass of the lamb (Gothé & Bezuidenhout, 1986). In spring there is a rapid rise in adult numbers (MacLeod, Colbo, Madbouly & Mwanaumo, 1977; Londt, Horak & De Villiers, 1979), probably because large numbers of overwintering nymphs moult synchronously. Sheep may thus be infested by both sexes simultaneously, which increases the possibility of paralysis occurring (Gothé & Budelmann, 1980). If very young lambs are present they may become heavily infested and because of their small body mass the chances of paralysis are further enhanced. With the exception of "Bucklands", where few *R. evertsi evertsi* were recovered after winter, adult tick numbers rose during October or November on all the survey farms. No cases of paralysis were seen as all the survey sheep, including the autumn-born (May) lambs on "Grasmere", were fairly large by that time.

The presence of several peaks in immature and adult abundance on the sheep during the course of the surveys indicate that 2 or more life cycles can be

completed annually, as suggested by Matson & Norval (1977) and Horak, Knight & De Vos (1986).

Rhipicephalus glabroscutatum

The geographic distribution of this 2-host tick has been illustrated by MacIvor (1985). The inland Valley Bushveld region in the eastern Cape Province is 1 of its preferred localities, and it was on "Bucklands" that substantial numbers of ticks were recovered.

Kudu are the preferred hosts of all stages of development of *R. glabroscutatum*, while cattle and Angora goats are better hosts than are Dorper sheep (Horak & Knight, 1986). Substantial numbers of immatures may also be recovered from scrub hares (Horak & Knight, 1986). On kudu on and around "Bucklands" the ratio of larvae to nymphs to adults was 11,2:6,0:1,0, whereas the ratio on Angora goats on the farm was 3,2:2,8:1,0 (Horak & Knight, 1986). On the Dorper sheep in the present survey it was 19,4:0,9:1,0 (Table 5). As in the case of *R. evertsi* on the Merino sheep, large numbers of *R. glabroscutatum* larvae died or detached before moulting to nymphs on the Dorper sheep. Consequently a large proportion of the adults on these sheep must have originated from nymphs that had fed on other animals, notably kudu and scrub hares.

The presence of the immature stages from late summer to spring, with a peak in numbers from April to September, and of adults from spring to late summer, is virtually identical to that recorded for this tick on goats running in Valley Bushveld near Uitenhage (MacIvor & Horak, 1984). This pattern of seasonal abundance indicates that only 1 life cycle is completed annually.

Rhipicephalus nitens

According to Morel (1969) *R. nitens* is restricted to the south-western Cape Province. In our experience its distribution extends to the south-eastern Cape Province at least as far as Grahamstown (26° 32' E) (Horak, Jacot Guillarmod, Moolman & De Vos, 1987). The recovery of *R. nitens* from sheep on the farms "Reed Valley", and more particularly "Sidbury", further confirms this. We suggest that the distribution of this tick is associated with vegetation described as macchia or fynbos even though this may be dominated by other vegetation types. On both "Reed Valley" and "Sidbury" fynbos-like vegetation is present.

In the Bontebok National Park in the south-western Cape Province all stages of development can be found on bontebok, grey rhebuck and scrub hares and the mean ratio of larvae, to nymphs to adults is 16,3:5,6:1,0 (Horak, Sheppey, Knight & Beuthin, 1986). On the sheep at Sidbury the ratio is 41,2:4,1:1,0, indicating a considerable reduction in numbers between the larval and nymphal stages. This is probably partly because numerous larvae die on the sheep, as discussed earlier. The Bontebok Park results may also have been biased in favour of a low larval ratio as the animals were slaughtered at 2-monthly intervals and the month of peak larval abundance could have been missed. Sheep must be considered good hosts of adult *R. nitens* as all animals harboured more than 30 ticks during the periods of peak adult abundance and approximately 1/7 of all female ticks recovered were maturing.

Horak, Sheppey, Knight & Beuthin (1986) remarked that in the Bontebok Park male *R. nitens* outnumbered females on their hosts early in the season of adult activity while the converse was true later

in the season. The same was true at "Sidbury" during January 1987 (late season) (70 males:100 females) but not January 1986 (108 males:48 females).

In the Bontebok Park, where rain falls mainly from autumn to spring, larvae reached peak numbers during April, nymphs during August and adults from December to February (Horak, Sheppey, Knight & Beuthin, 1986). At "Sidbury", where most of the rain falls from spring to autumn the larvae peaked during March/April, the nymphs during August to October and the adults from November to January. Seasonal abundance at the 2 localities was thus fairly similar despite the difference in rainfall patterns.

Rhipicephalus simus

Too few ticks were present for any meaningful conclusions to be drawn. However, all the ticks recovered were found on the lower legs and feet of the sheep.

ACKNOWLEDGEMENTS

We are most appreciative of the cooperation of Messrs F. J. Rabie, J. Weeks, H. Hart, J. Turner and W. A. Phillips, who not only made their farms available for running the experimental sheep, but also provided the labour necessary for the management of the sheep.

Miss Andrea van Niekerk of the Veterinary Research Institute, Onderstepoort drew the figures.

This research was funded by the Meat Board, Smith-Kline Animal Health, Bayer Animal Health, The Council for Scientific and Industrial Research, the Wool Board, the South African Nature Foundation and Rhodes University.

REFERENCES

- ACOCKS, J. P. H., 1975. Veld types of South Africa with accompanying veld type map. 2nd edn. *Memoirs of the Botanical Survey of South Africa*, No. 40, 128 pp.
- BEZUIDENHOUT, J. D., 1987. Natural transmission of heartwater. *Onderstepoort Journal of Veterinary Research*, 54, 349-351.
- DOWER, KATHY M., PETNEY, T. N. & HORAK, I. G., 1988. The developmental success of *Amblyomma hebraeum* and *Amblyomma marmoratum* on the leopard tortoise, *Geochelone pardalis*. *Onderstepoort Journal of Veterinary Research*, 55, 11-13.
- FOURIE, L. J., HORAK, I. G. & MARAIS, L., 1988. The seasonal abundance of adult ixodid ticks on Merino sheep in the south-western Orange Free State. *Journal of the South African Veterinary Association*, 59, 191-194.
- GÖTHE, R. & BUDELMANN, K., 1980. Zur toxischen Phase Paralyseinduzierender weiblicher *Rhipicephalus evertsi evertsi* Neumann, 1897, während der Repletion. *Zentralblatt für Veterinärmedizin*, B, 27, 524-543.
- GÖTHE, R. & BEZUIDENHOUT, J. D., 1986. Studies on the ability of different strains or populations of female *Rhipicephalus evertsi evertsi* (Acarina: Ixodidae) to produce paralysis in sheep. *Onderstepoort Journal of Veterinary Research*, 53, 19-24.
- GRAY, J. S. & POTGIETER, F. T., 1981. The retention of *Babesia bigemina* infection by *Boophilus decoloratus* exposed to imidocarb dipropionate during engorgement. *Onderstepoort Journal of Veterinary Research*, 48, 225-227.
- HAMEL, H. D. & GÖTHE, R., 1987. Influence of infestation rate on tick-paralysis in sheep induced by *Rhipicephalus evertsi evertsi* Neumann, 1897. *Veterinary Parasitology*, 4, 183-191.
- HOOGSTRAAL, H., 1956. African Ixodoidea. 1. Ticks of the Sudan (with special reference to Equatoria Province and with preliminary reviews of the genera *Boophilus*, *Margaropus* and *Hyalomma*). Department of the Navy, Bureau of Medicine and Surgery, Washington D.C. 1 101 pp.
- HORAK, I. G., MELTZER, D. G. A. & DE VOS, V., 1982. Helminth and arthropod parasites of springbok, *Antidorcas marsupialis*, in the Transvaal and western Cape Province. *Onderstepoort Journal of Veterinary Research*, 49, 7-10.

- HORAK, I. G., POTGIETER, F. T., WALKER, JANE B., DE VOS, V. & BOOMKER, J., 1983. The ixodid tick burdens of various large ruminant species in South African nature reserves. *Onderstepoort Journal of Veterinary Research*, 50, 221–228.
- HORAK, I. G., DE VOS, V. & BROWN, MOIRA R., 1983. Parasites of domestic and wild animals in South Africa. XVI. Helminth and arthropod parasites of blue and black wildebeest (*Connochaetes taurinus* and *Connochaetes gnou*). *Onderstepoort Journal of Veterinary Research*, 50, 243–255.
- HORAK, I. G., DE VOS, V. & DE KLERK, B. D., 1984. Parasites of domestic and wild animals in South Africa. XVII. Arthropod parasites of Burchell's zebra, *Equus burchelli*, in the eastern Transvaal Lowveld. *Onderstepoort Journal of Veterinary Research*, 51, 145–154.
- HORAK, I. G. & WILLIAMS, E. J., 1986. Parasites of domestic and wild animals in South Africa. XVIII. The crowned guinea fowl (*Numida meleagris*), an important host of immature ixodid ticks. *Onderstepoort Journal of Veterinary Research*, 53, 119–122.
- HORAK, I. G., KNIGHT, M. M. & DE VOS, V., 1986. Parasites of domestic and wild animals in South Africa. XX. Arthropod parasites of the Cape mountain zebra (*Equus zebra zebra*). *Onderstepoort Journal of Veterinary Research*, 53, 127–132.
- HORAK, I. G., SHEPPEY, K., KNIGHT, M. M. & BEUTHIN, C. L., 1986. Parasites of domestic and wild animals in South Africa. XXI. Arthropod parasites of vaal ribbok, bontebok and scrub hares in the western Cape Province. *Onderstepoort Journal of Veterinary Research*, 53, 187–197.
- HORAK, I. G. & KNIGHT, M. M., 1986. A comparison of the tick burdens of wild animals in a nature reserve and on an adjacent farm where tick control is practised. *Journal of the South African Veterinary Association*, 57, 199–203.
- HORAK, I. G. & MACIVOR, K. M. DE F., 1987. The scrub hare, a reliable indicator of the presence of *Hyalomma* ticks in the Cape Province. *Journal of the South African Veterinary Association*, 58, 15–19.
- HORAK, I. G., MACIVOR, K. M. DE F., PETNEY, T. N. & DE VOS, V., 1987. Some avian and mammalian hosts of *Amblyomma hebraeum* and *Amblyomma marmoreum* (Acari: Ixodidae). *Onderstepoort Journal of Veterinary Research*, 54, 397–403.
- HORAK, I. G., JACOT GUILLARMOD, AMY, MOOLMAN, L. C. & DE VOS, V., 1987. Parasites of domestic and wild animals in South Africa. XXII. Ixodid ticks on domestic dogs and on wild carnivores. *Onderstepoort Journal of Veterinary Research*, 54, 573–580.
- HORAK, I. G., KEEP, M. E., SPICKETT, A. M. & BOOMKER, J., 1989. Parasites of domestic and wild animals in South Africa. XXIV. Arthropod parasites of bushbuck and common duiker in the Weza State Forest, Natal. *Onderstepoort Journal of Veterinary Research*, 56, 63–66.
- HOWELL, C. J., WALKER, JANE B. & NEVILL, E. M., 1978. Ticks, mites and insects infesting domestic animals in South Africa. I. Description and biology. Department of Agricultural Technical Services, Republic of South Africa, Science Bulletin No. 393, v + 69 pp.
- KNIGHT, M. M. & RECHAV, Y., 1978. Ticks associated with kudu in the eastern Cape: Preliminary report. *Journal of the South African Veterinary Association*, 49, 343–344.
- LONDT, J. G. H., HORAK, I. G. & DE VILLIERS, I. L., 1979. Parasites of domestic and wild animals in South Africa. XIII. The seasonal incidence of adult ticks (Acari: Ixodidae) on cattle in the northern Transvaal. *Onderstepoort Journal of Veterinary Research*, 46, 31–39.
- MACIVOR, K. M. DE F. & HORAK, I. G., 1984. The internal and external parasites of Angora and Boer goats in Valley Bushveld near Uitenhage. *Angora Goat and Mohair Journal*, 26, 7–14.
- MACIVOR, K. M. DE F., 1985. The distribution and hosts of *Rhipicephalus glabroscutatum*. *Onderstepoort Journal of Veterinary Research*, 52, 43–46.
- MACLEOD, J., COLBO, M. H., MADBOULY, M. H. & MWANAUMO, B., 1977. Ecological studies of ixodid ticks (Acari: Ixodidae) in Zambia. III. Seasonal activity and attachment sites on cattle, with notes on other hosts. *Bulletin of Entomological Research*, 67, 161–173.
- MATSON, B. A. & NORVAL, R. A. I., 1977. The seasonal occurrence of adult ixodid ticks on cattle on a Rhodesian highveld farm. *Rhodesian Veterinary Journal*, 8, 2–6.
- MOREL, P. C., 1969. Contribution à la connaissance de la distribution des tiques (Acariens, Ixodidae et Amblyommidae) en Afrique éthiopienne continentale. Annexe cartographique, cartes 1–62. Institut d'Élevage et de Médecine Vétérinaire des Pays Tropicaux, Maisons-Alfort.
- NORVAL, R. A. I., 1975. Studies on the ecology of *Amblyomma marmoreum* Koch 1844 (Acarina: Ixodidae). *Journal of Parasitology*, 61, 737–742.
- NORVAL, R. A. I., 1981. The ticks of Zimbabwe. III. *Rhipicephalus evertsi evertsi*. *Zimbabwe Veterinary Journal*, 12, 31–35.
- NORVAL, R. A. I., 1983. The ticks of Zimbabwe. VII. The genus *Amblyomma*. *Zimbabwe Veterinary Journal*, 14, 3–18.
- NORVAL, R. A. I., 1984. The ticks of Zimbabwe. IX. *Haemaphysalis leachi* and *Haemaphysalis spinulosa*. *Zimbabwe Veterinary Journal*, 15, 9–17.
- PETNEY, T. N., HORAK, I. G. & RECHAV, Y., 1987. The ecology of the African vectors of heartwater, with particular reference to *Amblyomma hebraeum* and *Amblyomma variegatum*. *Onderstepoort Journal of Veterinary Research*, 54, 381–395.
- PETNEY, T. N. & HORAK, I. G., 1987. The effect of dipping on free-living and parasitic populations of *Amblyomma hebraeum* on a farm and on an adjacent nature reserve. *Onderstepoort Journal of Veterinary Research*, 54, 529–533.
- POTGIETER, F. T., 1977. The life cycle of *Babesia bovis* and *Babesia bigemina* in ticks and in cattle in South Africa. Ph.D. Thesis, Rand Afrikaans University.
- RECHAV, Y., 1982. Dynamics of tick populations (Acari: Ixodidae) in the eastern Cape Province. *Journal of Medical Entomology*, 19, 679–700.
- RECHAV, Y., 1986. Seasonal activity and hosts of the vectors of Crimean-Congo haemorrhagic fever in South Africa. *South African Medical Journal*, 69, 364–368.
- ROBERTSON, WENDY D., 1981. A four year study of the seasonal fluctuations in the occurrence of the blue tick, (*Boophilus decoloratus* (Koch)), in the coastal regions of the eastern Cape. *Proceedings of the International Conference on Tick Biology and Control, Grahamstown, South Africa, 27–29 January 1981*, 199–204.
- STAMPA, S., 1959. Tick paralysis in the Karoo areas of South Africa. *Onderstepoort Journal of Veterinary Research*, 28, 169–227 + map.
- THEILER, GERTRUD, 1962. The Ixodoidea parasites of vertebrates in Africa south of the Sahara (Ethiopian Region). Project S.9958. Report to the Director of Veterinary Services, Onderstepoort. Mimeographed.
- WAGLAND, B. M., 1979. Host resistance to cattle tick (*Boophilus microplus*) in Brahman (*Bos indicus*) cattle. IV. Ages of ticks rejected. *Australian Journal of Agricultural Research*, 30, 211–218.
- WALKER, JANE B., 1974. The ixodid ticks of Kenya. London: Commonwealth Institute of Entomology.
- YEOMAN, G. H. & WALKER, JANE B., 1967. The ixodid ticks of Tanzania. London: Commonwealth Institute of Entomology.