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PARASITES OF DOMESTIC AND WILD ANIMALS IN SOUTH AFRICA. XXX. ECTOPARASITES OF KUDUS IN THE EASTERN TRANSVAAL LOWVELD AND THE EASTERN CAPE PROVINCE

I. G. HORAK[1], J. BOOMKER[2], A. M. SPICKETT[3] and V. DE VOS[4]

ABSTRACT

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Sets of four kudus were shot and examined for arthropod parasites at approximately monthly intervals from April 1981 to March 1983 in the southern part of the Kruger National Park, eastern Transvaal Lowveld. These animals harboured 10 ixodid tick species of which *Boophilus decoloratus* followed by *Amblyomma hebraeum* were the most abundant. The seasonal abundances of these ticks and of *Amblyomma marmoreum, Rhipicephalus appendiculatus, Rhipicephalus evertsi evertsi* and *Rhipicephalus zambeziensis* were determined. The kudus were also infested with 3 lice and 1 louse fly species, as well as the nymphs of a pentastomid.

Sixteen kudus were shot in the Andries Vosloo Kudu Reserve, eastern Cape Province and 9 on an adjacent farm. These animals were infested with 12 tick species. *A. hebraeum* followed by *Rhipicephalus glabroscutatum* were the most abundant on kudus in the reserve and *R. glabroscutatum* followed by *Haemaphysalis silacea* on the animals on the farm. The seasonal abundances of *A. hebraeum,A. marmoreum, H. silacea, R. appendiculatus, R. glabroscutatum* and a *Rhipicephalus* sp. (near *R. oculatus*) were determined on the kudus in the reserve. The kudus were also infested with 3 lice and 1 louse fly species. Two kudus examined in the Addo Elephant National Park were infested with 6 tick, 1 louse and 1 louse fly species.

INTRODUCTION

A number of surveys on the abundance of ectoparasites on a variety of host species have already been conducted in the eastern Transvaal Lowveld and the eastern Cape Province. Blue wildebeest, Burchell's zebras, warthogs and helmeted guineafowls have been examined in the Kruger National Park, eastern Transvaal Lowveld (Horak, De Vos & Brown, 1983; Horak, De Vos & De Klerk, 1984; Horak, Boomker, De Vos & Potgieter, 1988; Horak, Spickett, Braack & Williams, 1991). While kudus, cattle, Dorper sheep, Angora goats, scrub hares and helmeted guineafowls have been examined in the Andries Vosloo Kudu Reserve and/or on the adjacent farm "Bucklands", eastern Cape Province (Knight & Rechav, 1978; Rechav, 1982; Horak, Williams & Van Schalkwyk, 1991; Horak, Spickett, Braack & Williams, 1991; Horak, Knight & Williams, 1991; Horak & Fourie, 1991).

Several studies on the ixodid tick burdens of kudus, *Tragelaphus strepsiceros,* have been published. Knight & Rechav (1978) examined 25 animals from the farms "Bucklands" and "Ulster" and Horak, Potgieter, Walker, De Vos & Boomker (1983) 4 animals in the Kruger National Park and 5 from the Andries Vosloo Kudu Reserve. Horak & Knight (1986) and Petney & Horak (1987) also compared the burdens of some of the animals from the Andries Vosloo Kudu Reserve, included in the present paper, with those of kudus on the adjacent farm "Bucklands". These surveys all indicate that kudus are good hosts of several tick species and may become heavily infested, a fact also commented on by Lightfoot & Norval (1981) in Zimbabwe.

Kudus are large antelope that are widely distributed in southern and East Africa. They prefer light forest or dense bush (Ansell, 1971) and generally avoid open country (Dorst & Dandelot, 1972; Rautenbach, 1982). They usually live in small groups comprising adult cows and their offspring. Calves remain hidden for approximately the first 3 months of life and then join the cow groups (Novellie, 1983). Male animals leave the group when about 2 years old, while females stay with the group until fully mature (Novellie, 1983). Adult bulls form bachelor groups that join the cows during the breeding season (Novellie, 1983).

The present paper describes surveys on the abundance of ectoparasites of kudus shot in the Kruger National Park, eastern Transvaal Lowveld, in the Andries Vosloo Kudu Reserve and on the adjacent farm "Bucklands", and in the Addo Elephant National Park, eastern Cape Province. The kudus in these surveys were also examined for internal parasites and this has been reported elsewhere (Boomker, Horak & De Vos, 1989; Boomker, Horak & Knight, 1991).

MATERIALS AND METHODS

Parasite recovery

After the animals had been shot they were transported to the laboratories at Skukuza in the Kruger National Park or Grahamstown in the eastern Cape Province. There the carcass of each animal was skinned and half the skin of the head, half the skin of the body and upper legs, the whole skin of the tail as well as 1 lower front leg and 1 lower back leg with skin attached were placed separately in plastic bags. A tick-detaching agent[1] was added

[1] Faculty of Veterinary Science, University of Pretoria, Onderstepoort 0110

[2] Faculty of Veterinary Science, Medical University of Southern Africa, Medunsa 0204

[3] Veterinary Research Institute, Onderstepoort 0110

[4] National Parks Board, Skukuza 1350

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TABLE 1 Arthropod parasites of 95 kudus in the Kruger National Park

Arthropod species	Total number recovered					No. of kudus infested
Ixodid ticks	Larvae	Nymphs	Males	Females	Total	
Amblyomma hebraeum	67 216	9 801	659	291(9)	77 967	95
Amblyomma marmoreum	465	0	0	0	465	18
Boophilus decoloratus	161 815	107 711	35 959	18 140(360)	323 625	95
Haemaphysalis leachi/spinulosa	1	0	0	0	1	1
Hyalomma truncatum	0	0	30	6	36	16
Ixodes sp.	2	1	0	0	3	2
Rhipicephalus appendiculatus	11 915	3 208	3 062	1 721(31)	19 906	88
Rhipicephalus evertsi evertsi	9 015	940	167	63(2)	10 185	92
Rhipicephalus simus	0	0	6	9	15	5
Rhipicephalus zambeziensis	14 365	2 062	963	485(7)	17 875	91
Lice	Nymphs		Adults		Total	
Damalinia sp.	4 336		2 375		6 711	73
Haematopinus taurotragi	470		413		883	23
Linognathus taurotragus	4 782		2 781		7 563	43
Louse flies	Adults				Total	
Lipoptena paradoxa	4 616				4 616	94
Pentastomids	Nymphs				Total	
Linguatula nuttalli	667				667	60

( ) = Number of maturing females i.e. idiosoma of *A. hebraeum* >9,5 mm; *B. decoloratus* >4,0 mm; *R. appendiculatus* >5,0 mm; *R. evertsi evertsi* >6,0 mm; *R. zambeziensis* >5,0 mm. Females of the other tick species had not started to mature

to the skins in the bags which were tightly secured and stored overnight. The following morning the skins were thoroughly scrubbed with brushes with steel bristles and washed. The tick-detaching agent remaining in the plastic bags and the material obtained from scrubbing and washing the skins were sieved on sieves with 0,15 mm apertures. The residues in the sieves were collected, preserved in 10 % formalin and stored.

Pentastomid nymphs were recovered from the hearts, livers and lungs of the kudus, which had all been processed for helminth recovery (Boomker *et al.*, 1989).

Parasite counts

Representative samples of the material collected were examined under a stereoscopic microscope, and the parasites identified and counted. The remainder of the material was examined macroscopically for the presence of adult ticks and louse flies. These and the pentastomid nymphs recovered from the hearts, livers and lungs were counted and identified under a stereoscopic microscope. The data on the louse flies will be reported separately.

Surveys at Particular Localities

Kruger National Park (KNP)

Study site

This has been described in some detail by Boomker *et al.* (1989). In summary, it is located in the southern part of the park between latitude 25° 06′–25° 21′ S and longitude 31° 27′–31° 36′ E. The vegetation is classified as Lowveld (Acocks, 1988). The days are warm to hot in summer and mild in winter and frost occurs occasionally. Rainfall varies from 600–700 mm per annum and usually falls in summer.

Survey animals

Each month from April 1981 to March 1983, 4 kudus were shot in the study area. At each occasion an attempt was made to obtain 1 adult male, 1 adult female, 1 young or sub-adult male and 1 calf of either sex. The animals were aged according to Simpson (1971). For statistical reasons they have been grouped according to age into calves (0–12 months old), juveniles (13–24 months old), young adults (25–48 months old) and prime or old adults (49 months and older). A total of 96 kudus were shot, but only 95 were examined for ectoparasites as the material collected from 1 had not been adequately preserved.

Arthropod burdens

The total numbers of arthropod parasites recovered from the kudus shot in the survey area are summarized in Table 1.

The animals were infested with 10 ixodid tick species. *Boophilus decoloratus* and *A. hebraeum* were the most abundant and all kudus were infested. They were also infested with 3 lice and 1 louse fly species.

Seasonal abundance

The seasonal abundances of *A. hebraeum, Amblyomma marmoreum, B. decolaratus, Rhipicephalus appendiculatus, Rhipicephalus evertsi evertsi* and *Rhipicephalus zambeziensis* on the kudus are graphically illustrated in Fig. 1.

A. hebraeum exhibited no clear pattern of seasonal abundance, while the larvae of *A. marmoreum* were consistently present from March to July 1982 and during February and March 1983. Peak burdens of *B. decoloratus* were recorded in September and October 1981, and November and December

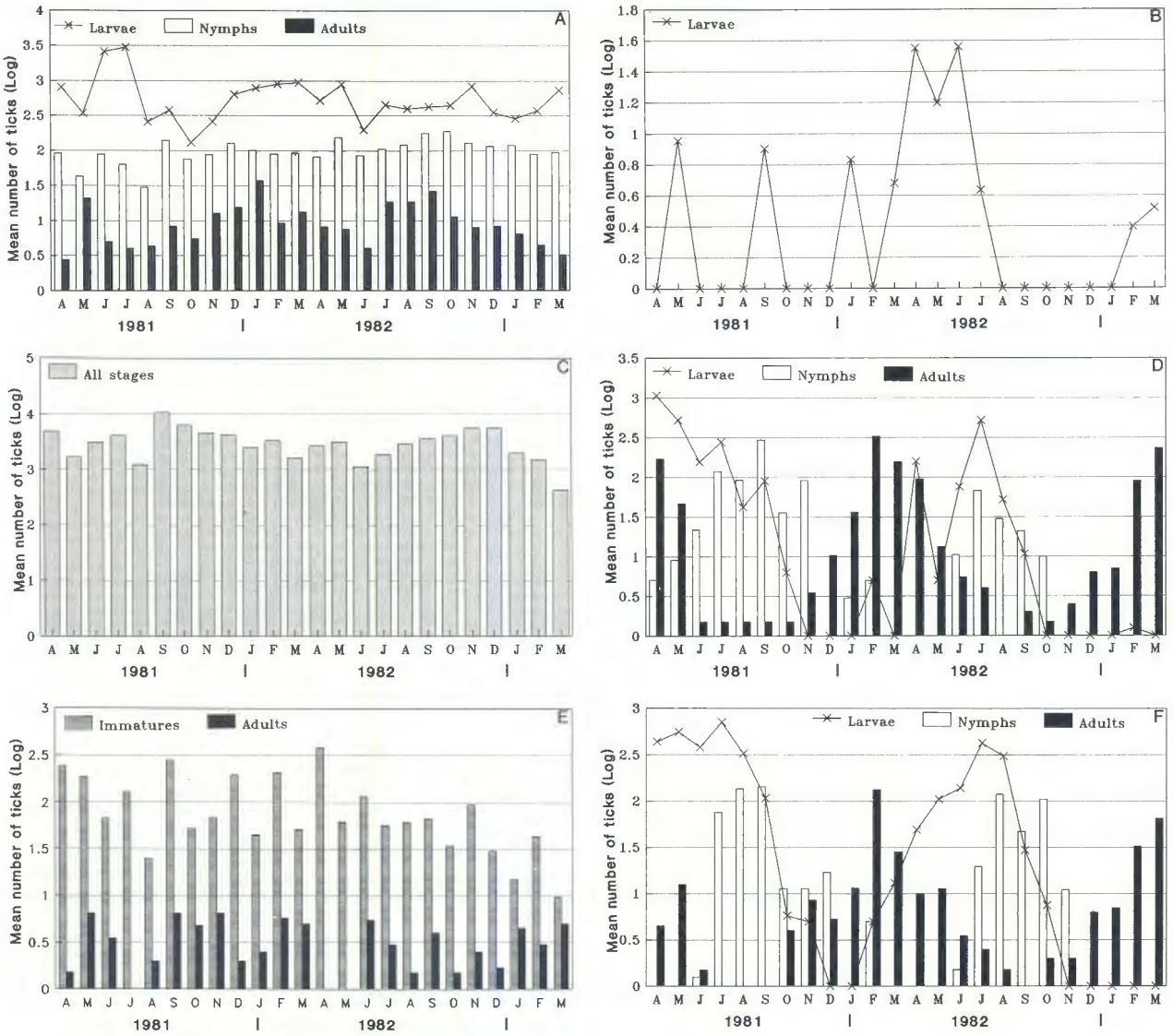

FIG. 1 The seasonal abundance of
A. *Amblyomma hebraeum,* B. *Amblyomma marmoreum,* C. *Boophilus decoloratus,* D. *Rhipicephalus appendiculatus,* E. *Rhipicephalus evertsi evertsi* and F. *Rhipicephalus zambeziensis* on kudus in the Kruger National Park

1982. The larvae of *R. appendiculatus* reached the largest numbers from April to July, the nymphs from July to September or November, and the adults during February to April. No clear pattern of seasonal abudance was evident for *R. evertsi evertsi.* Large numbers of larvae of *R. zambeziensis* were present from April to September, nymphs from July to September or October and adults during February and March.

Host sex-preferences

The host sex-preferences of *A. hebraeum* and *B. decoloratus* are summarized in Table 2.

Adult male kudus harboured significantly more nymphs, males and females of *A. hebraeum,* and more males and females of *B. decoloratus* than adult female animals. No such differences were noted for the other tick species or between adult animals and calves of 6 months or less of age.

Andries Vosloo Kudu Reserve (AVKR) and the farm "Bucklands"

Study site

The reserve (6 497 ha in extent) and the farm (5 480 ha), share an 11 km common boundary, and are situated in the eastern Cape Province around 33° 07 ′ S and 26° 40′ E with altitudes ranging from 335–538 m. The vegetation is classified as Valley Bushveld (Acocks, 1988). 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 reserve contained approximately 450 kudus, 54 hartebeest, 140 eland and 100 buffaloes, and the farm approximately 300 kudus, 300 Dorper sheep, 4 000 Angora goats and 185 cattle. The domestic stock were regularly treated with an acaricide. Both properties harboured

TABLE 2 A comparison of the burdens of *Amblyomma hebraeum* and *Boophilus decoloratus* of 15 adult male and 15 adult female kudus shot in pairs during the same months and in the same locality, using a Wilcoxon matched-pairs signed-ranks test

Tick species	Develop-mental stage	Mean number of ticks recovered from adult kudus		Wilcoxon T value	Significance P =
		Male kudus	Female kudus		
Abmlyomma hebraeum	Nymphs	144,7	103,2	20,0	0,050
	Males	22,1	2,8	0,0	0,001
	Females	11,1	0,5	0,0	0,001
Boophilus decoloratus	Males	503,7	338,2	24,0	0,050
	Females	302,3	154,2	15,0	0,050

TABLE 3 Arthropod parasites of 16 kudus in the Andries Vosloo Kudu Reserve

Arthropod species	Total number recovered					No. of kudus infested
Ixodid ticks	Larvae	Nymphs	Males	Females	Total	
Amblyomma hebraeum	32 009	3 568	464	252(22)	36 293	16
Amblyomma marmoreum	2 112	0	0	0	2 112	11
Boophilus decoloratus	8	36	34	20	98	5
Haemaphysalis silacea	10 003	2 309	1 410	415(66)	14 137	16
Hyalomma marginatum rufipes	0	0	3	0	3	1
Hyalomma truncatum	0	0	2	0	2	1
Ixodes pilosus	0	14	2	12	28	4
Rhipicephalus appendiculatus	4 391	775	334	180(24)	5 680	16
Rhipicephalus evertsi evertsi	296	145	18	10	469	16
Rhipicephalus glabroscutatum	13 596	7 269	1 043	544(20)	22 452	16
Rhipicephalus sp. (near *R. oculatus*)	0	0	104	41(14)	145	13
Rhipicephalus simus	0	0	2	4	6	2
Lice	Nymphs		Adults		Total	
Haematopinus taurotragi	486		92		578	4
Linognathus taurotragus	1 895		784		2 679	16
Louse flies	Adults				Total	
Lipoptena paradoxa	108				108	13

( ) = Number of maturing females i.e. idiosoma of *A. hebraeum* >9,5 mm; *H. silacea* >5,0 mm; *R. appendiculatus* >5,0 mm; *R. glabroscutatum* >4,0 mm; *Rhipicephalus* sp. (near *R. oculatus*) >5,0 mm in length. Females of the other tick species had not started to mature

large numbers of small antelope, scrub hares and helmeted guineafowls.

Survey animals

Each month, from February 1985 to January 1986, and every 3 months thereafter, commencing March 1986 until December 1986, a single adult male kudu was shot on the reserve. With the exeption of June 1985 when 2 kudus were shot, 1 adult male kudu was shot on "Bucklands" every 3 months from March 1985 until December 1986. In this way 16 kudus on the reserve and 9 kudus on the farm where shot and examined.

Arthropod burdens

The total numbers of arthropod parasites recovered from kudus on the reserve and on the farm are summarized in Tables 3 and 4 respectively.

The kudus on the reserve were infested with 12 ixodid tick species of which *A. hebraeum* followed by *Rhipicephalus glabroscutatum* were the most abundant. The animals on the farm were infested with 9 tick species of which *R. glabroscutatum* followed by *Haemaphysalis silacea* were the most abundant. The kudus were infested with 3 lice and 1 louse fly species.

Seasonal abundance

The seasonal abundances of *A. hebraeum, A. marmoreum, H. silacea, R. appendiculatus, R. evertsi evertsi, R. glabroscutatum* and a *Rhipicephalus* sp. (near *R. oculatus*) on only those kudus which were shot from February 1985 to January 1986 in the reserve, are graphically represented in Fig. 2.

The largest numbers of larvae of *A. hebraeum* were present from March to May and during July 1985, nymphs during March, November and December and adults during December. Peak numbers of larvae of *A. marmoreum* were present during February, April and May 1985. The larvae of *H. silacea* reached peak numbers from February to August and during December 1985 and January 1986, the nymphs from May to August 1985 and the adults during August and October 1985. The larvae of *R. appendiculatus* reached the largest numbers from March to June, the nymphs from June to October and the adults from February to April 1985 and during January 1986. The immature stages of *R. evertsi evertsi* were at their lowest from August to November. Large numbers of immature *R. glabroscutatum,* a 2-host tick, were present from March to

TABLE 4 Arthropod parasites of 9 kudus on the farm "Bucklands", eastern Cape Province

Arthropod species	Total number recovered					No. of kudus infested
Ixodid ticks	Larvae	Nymphs	Males	Females	Total	
Amblyomma hebraeum	157	24	14	4	199	7
Amblyomma marmoreum	54	2	0	0	56	5
Boophilus decoloratus	43	34	21	4	102	3
Haemaphysalis silacea	1 994	783	410	112(16)	3 299	9
Hyalomma marginatum rufipes	0	0	2	0	2	1
Rhipicephalus appendiculatus	1 638	796	70	20	2 524	9
Rhipicephalus evertsi evertsi	92	130	20	1	243	8
Rhipicephalus glabroscutatum	11 460	5 980	580	236(16)	18 256	9
Rhipicephalus sp. (near *R. oculatus*)	0	0	30	13	43	6
Lice	Nymphs		Adults		Total	
Damalinia sp.	16		0		16	1
Haematopinus taurotragi	30		22		52	1
Linognathus taurotragus	1 344		525		1 869	9
Louse flies	Adults				Total	
Lipoptena paradoxa	68				68	7

( ) = Number of maturing females, i.e. idiosoma of *H. silacea* >5,0 mm; *R. glabroscutatum* >4,0 mm in length. Females of the other tick species had not started to mature

TABLE 5 The mean numbers of ticks recovered from kudus examined during the same months in the Andries Vosloo Kudu Reserve and on the farm "Bucklands"

Ixodid tick species	Mean numbers of ticks recovered					
	Kudus in Kudu Reserve			Kudus on "Bucklands"		
	Larvae	Nymphs	Adults	Larvae	Nymphs	Adults
Amblyomma hebraeum	3 188	325	66	17	3	2
Amblyomma marmoreum	119	0	0	6	0,2	0
Boophilus decoloratus	0	0	3	5	4	3
Haemaphysalis silacea	505	81	70	222	87	58
Hyalomma marginatum rufipes	0	0	0	0	0	0,2
Hyalomma truncatum	0	0	0,3	0	0	0
Ixodes pilosus	0	0	0,3	0	0	0
Rhipicephalus appendiculatus	489	63	20	182	88	10
Rhipicephalus evertsi evertsi	21	11	1	10	14	2
Rhipicephalus glabroscutatum	873	376	113	1 273	664	91
Rhipicephalus sp. (near *R. oculatus*)	0	0	8	0	0	5
Rhipicephalus simus	0	0	0,5	0	0	0

August and adults during February and from September to December 1985. The adults of the *Rhipicephalus* sp. (near *R. oculatus*) were present in all months except May and June.

The 9 kudus shot at 3-monthly intervals (2 during June 1985) on the farm "Bucklands" could be paired with 8 animals shot during the same months in the adjacent AVKR. The burdens of these animals are compared in Table 5.

With the exeption of the larvae, nymphs and males of *A. behraeum,* for which the differences were significant, such differences between the farm and the reserve were not evident for any of the other tick species.

Addo Elephant National Park

Study site

The park is located in the eastern Cape Province at 33 ° 30 ′ S; 25 ° 45′ E and the vegetation is described as Valley Bushveld (Acocks, 1988).

Survey animals

Two adult male kudus were shot in this reserve during April 1985.

Arthropod burdens

The kudus were infested with 6 ixodid tick species, 1 louse and 1 louse fly species (Table 6).

More than 90 % of the tick population on the kudus consisted of *A. hebraeum.*

DISCUSSION

General observations

Utech, Seifert & Wharton (1978) and Sutherst, Wharton, Cook, Sutherland & Bourne (1979) found that the calves of domestic cattle carried fewer *Boophilus microplus* than their dams. Although the kudu calves were not necessarily the offspring of the kudu females shot during the same months in the Kruger National Park, comparisons of the calves' tick burdens with those of the females were nevertheless made. It was possible to pair 16 calves aged

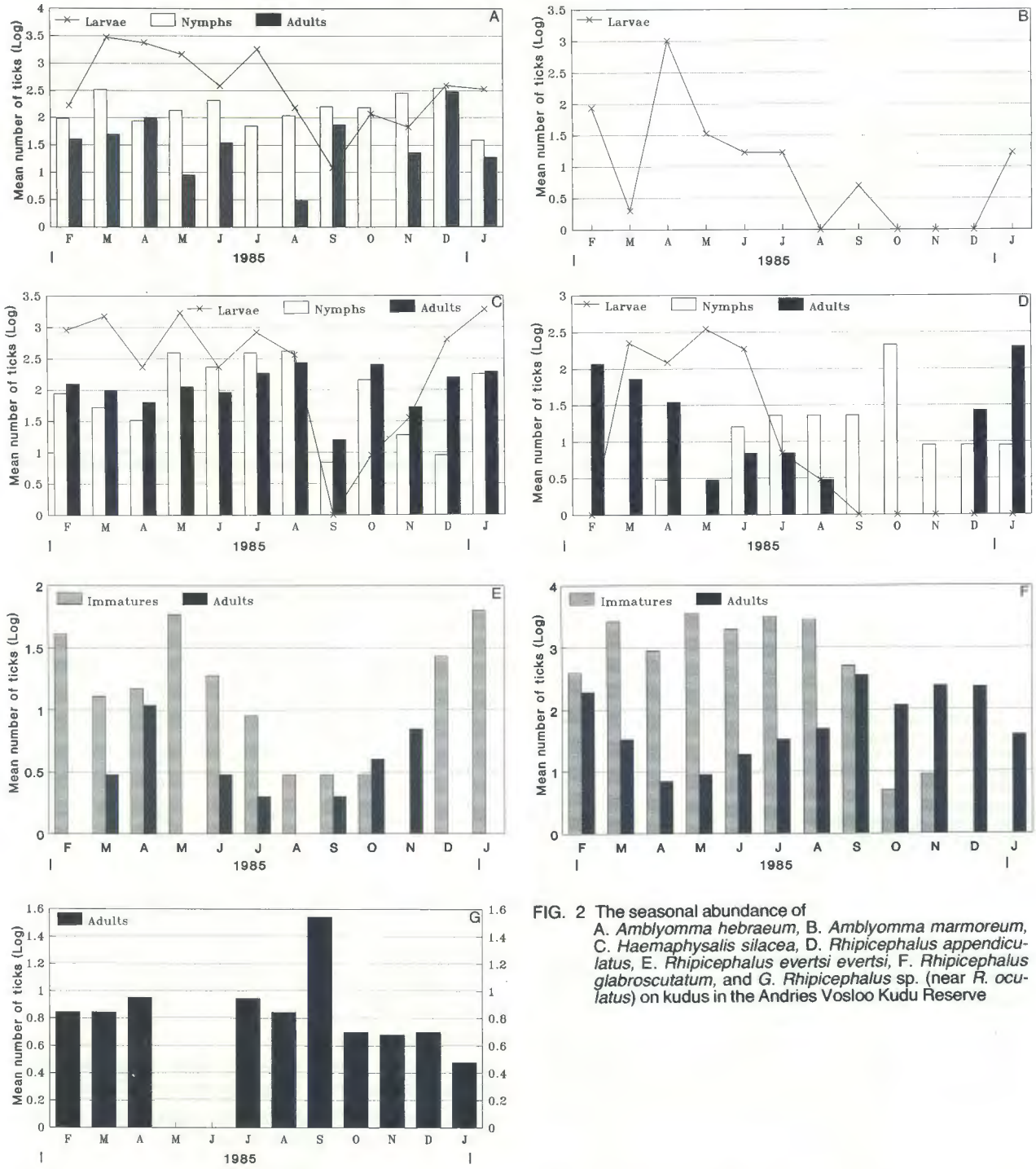

FIG. 2 The seasonal abundance of A. *Amblyomma hebraeum*, B. *Amblyomma marmoreum*, C. *Haemaphysalis silacea*, D. *Rhipicephalus appendiculatus*, E. *Rhipicephalus evertsi evertsi*, F. *Rhipicephalus glabroscutatum*, and G. *Rhipicephalus* sp. (near *R. oculatus*) on kudus in the Andries Vosloo Kudu Reserve

6 months or less with 16 adult females shot during the same months. No significant differences between the tick burdens of the calves and those of the cows were recorded. In fact, if one considers the size of the young calves compared with that of the cows, it would seem as if they are more prone to infestation than the cows.

Seifert (1971) recorded considerably more *B. microplus* on bulls than on domestic cows. He suggested that this strongly implies an influence of sex hormones on resistance. Our findings in the KNP show that adult male kudus carry significantly more nymphs (P=0,05), and males and females (P=0,001) of *A. hebraeum* and males and females (P=0,05) of *B. decoloratus* than do adult female animals. No such differences were recorded for any of the other tick species.

Horak, MacIvor, Petney & De Vos (1987) have suggested that the larger the host animal species the more likely it is to carry greater numbers of adult

TABLE 6 Arthropod parasites of 2 kudus in the Addo Elephant National Park

Arthropod species	Total number recovered					No. of kudus infested
Ixodid ticks	Larvae	Nymphs	Males	Females	Total	
Amblyomma hebraeum	14 957	1 165	30	10	16 162	2
Amblyomma marmoreum	17	0	0	0	17	2
Haemaphysalis silacea	985	125	119	44(4)	1 273	2
Hyalomma truncatum	0	0	1	0	1	1
Rhipicephalus evertsi evertsi	213	138	7	3	361	2
Rhipicephalus glabroscutatum	2	32	0	0	34	1
Lice	Nymphs		Adults		Total	
Linognathus taurotragus	22		6		28	1
Louse flies	Adults				Total	
Lipoptena paradoxa	11				11	2

( ) = Number of maturing females, i.e. idiosoma of *H. silacea* >5,0 mm in length. Females of the other tick species had not started to mature

A. hebraeum. The larger size of male kudus when compared to females may thus partially be responsible for the greater number of adult *A. hebraeum* carried by the former animals.

Kudus are good hosts of the immature stages of a large number of tick species (Horak & Knight, 1986; Tables 1 and 3). They are also good hosts of the adults of some species, such as *B. decoloratus, H. silacea, R. appendiculatus, R. glabroscutatum, R. zambeziensis* and a *Rhipicephalus* sp. (near *R. oculatus*). In addition adult male kudus must be considered good hosts of adult *A. hebraeum*.

Acaricidal treatment of the domestic livestock on "Bucklands" significantly affected the burdens only of *A. hebraeum* of kudus on the farm. This was probably due to the fact that cattle on the farm, which would have been good hosts for the adults of *A. hebraeum* as well as the other species, and the sheep and goats, which, with the exception of *R. glabroscutatum*, are generally poor hosts of the adults of most species, were all regularly treated with an acaricide and hence were poor hosts of all species. Thus, only the kudus, which, with the possible exception of the males, are not good hosts of adult *A. hebraeum*, but are good hosts of the adults of the other tick species, would have been largely responsible for maintaining the population of *A. hebraeum* on the farm. Petney & Horak (1987) state that the kudus clearly maintain a small but seemingly stable population of *A. hebraeum* on "Bucklands".

The eland and buffaloes on the reserve are very good hosts of adult *A. hebraeum* and individual animals may harbour more than 1 000 adult ticks (Horak, MacIvor, Petney & De Vos, 1987). They are also good hosts of the adults of the other tick species. These animals would largely be responsible for the large total burdens of *A. hebraeum* on the kudus on the reserve and they and the kudus themselves for the total burdens of the other tick species on the kudus.

The role kudus may play as reservoir hosts of ticks infesting cattle in mixed cattle and game ranching operations will depend on the population density of the former animals. As kudus are browsers (Owen-Smith, 1979; Novellie, 1983) their densities will be dependent upon the amount and quality of available browse. Thus in the Valley Bushveld of the eastern Cape Province where browse, particularly the spekboom *(Portulacaria afra)* is abundant, kudu density can be considerably higher than in the north-eastern Transvaal. Conventional stock fences do not serve as a barrier to kudus and consequently they could also disseminate ticks over considerable distances and several farms.

Both the tick reservoir status of kudus and their mobility could be advantageous to the stock farmer in that they could serve as a source of infected ticks on a cattle farm. This would help maintain immunity to diseases such as babesiosis *(Babesia bigemina)* and heartwater *(Cowdria ruminantium)* in cattle otherwise kept relatively tick-free by regular acaricidal treatment.

Amblyomma hebraeum

The 28 adult male kudus examined in the KNP harboured a mean of 1 003 larvae, 131 nymphs, 16 males and 8 females of this tick compared with 2 001, 223, 29 and 16, respectively, for the 16 males examined in the AVKR. The latter burdens were almost exactly double the former for each life stage as well as for the total. The larval:nymphal:adult ratio was virtually identical for male kudus on the 2 reserves being approximately 44:5:1.

This tick was introduced into the eastern Cape Province during the 1830's, probably on cattle from Zululand (Theiler, 1975; Provost & Bezuidenhout, 1987). The large numbers recovered from the kudus in this region confirm that it has become well established there. The fact that the kudus in the AVKR harboured nearly twice the burdens of those in the KNP does not, however, imply that the former habitat is more favourable than the latter; it is more a reflection of stocking density. The KNP is close to 2 M ha in extent and contains approximately 15 000 kudus, 400 eland, 30 000 buffaloes and 8 000 giraffes (all good hosts of adult *A. hebraeum*) resulting in an approximate stocking density of 1 of these animals per 37 ha. In the Kudu Reserve the approximate

stocking density for kudus, eland and buffaloes combined is 1 animal per 9,4 ha.

The immature stages of *A. hebraeum* have a wide host range (Theiler, 1962; Norval, 1974a). They utilize not only the same hosts as the adults, but a variety of small domestic and wild ruminants as well as scrub hares and helmeted guineafowls (Horak, MacIvor, Petney & De Vos, 1987). The higher stocking density in the AVKR is also reflected in the tick burdens of those hosts that harbour only immature stages; scrub hares had mean burdens of 46 larvae and 15 nymphs (Horak & Fourie, 1991) compared with 11 larvae and 11 nymphs on scrub hares in the KNP (Horak, Spickett & Braack, unpublished data). Helmeted guineafowls in the AVKR harboured 568 larvae and 26 nymphs, and those in the KNP 185 and 17 (Horak, Spickett, Braack & Williams, 1991). The hares, kudus and guineafowls in the AVKR were all examined at the same time, whereas in the KNP the hares and guineafowls were examined several years after the kudus.

If the number of immature ticks carried by female kudus and the smaller antelope as well as those harboured by scrub hares and guineafowls are taken into account the ratio of parasitic larvae and nymphs to adults will shift even further in favour of the immature stages.

The largest burden of adult ticks harboured by a single kudu was 72 males and 58 females recovered from a male shot in the KNP during January 1982 and 185 males and 119 females from a male shot in the AVKR during December 1985. The tick burdens of the 2 kudus examined in the Addo Elephant National Park indicate that burdens of *A. hebraeum* could possibly be even higher on kudus in this reserve than in either of the other reserves.

Despite only 1 animal being examined each month in the AVKR, larvae appeared to be more abundant during late summer and winter, nymphs during early summer and again in late summer and adults from early to late summer. This pattern of seasonal abundance corresponds to that observed by Knight & Rechav (1978) on kudus and by Rechav (1982) on cattle examined in the same locality, and is probably regulated by climate. In the KNP, where temperatures are higher than those in the eastern Cape Province, no clear pattern of seasonal abundance was evident and the tick's life cycle appeared to continue uninterrupted throughout the year.

Amblyomma marmoreum

Tortoises are the preferred hosts for all parasitic stages of this tick (Theiler, 1962; Norval, 1975b; Dower, Petney & Horak, 1988). Helmeted guineafowls, scrub hares, caracal, kudus, eland and cattle are all good hosts of the larvae if the numbers recovered and percentage of hosts infested are taken into account (Horak, MacIvor, Petney & De Vos, 1987; Horak & Fourie, 1991). With the possible exception of guineafowls, none of these animals are good hosts of the nymphs.

The large total number of larvae recovered from the kudus in the AVKR compared with those on "Bucklands" and in the KNP is due to 2 animals. One of these harboured 1 008 and the other 865 larvae.

The period of peak larval abundance (January to July) on kudus in the AVKR was longer than that on animals in the KNP (April to June). The seasonal abundance of larvae on helmeted guineafowls in the AVKR was similar to that on the kudus at the same locality, while that on guineafowls in the KNP extended from February or March to July or August (Horak, Spickett, Braack & Williams, 1991). The only nymphs recovered were from a kudu examined on "Bucklands" during December 1986.

Boophilus decoloratus

This was by far the most abundant tick on the kudus in the KNP, a finding also applicable to blue wildebeest and Burchell's zebras examined in this park (Horak, De Vos & Brown, 1983; Horak *et al.,* 1984). Drag-sampling of 32 of the 35 vegetation zones in the KNP during March 1988 indicated that *A. hebraeum* was the dominant species (Spickett, Horak, Braack & Van Ark, 1991), but this may well have been due to the month in which the samples were collected. Monthly drag-sampling of 2 vegetation zones near the study site over a period of 3 years, from 1988 to 1991, indicated that *R. zambeziensis* followed by *B. decoloratus* were most abundant in the zone north of the study site and *A. hebraeum* followed by *R. appendiculatus* and then *B. decoloratus* in the zone east of the study site (Horak, Spickett & Braack, unpublished data). Although it is possible that *B. decoloratus* was the dominant tick on the vegetation within the study area this seems unlikely in the light of the drag-sampling data from the 2 zones.

Two possible reasons for the large numbers of *B. decoloratus* on the kudus are, firstly that this is a 1-host tick, spending approximately 21 days on an animal in order to complete its parasitic life cycle (Londt & Spickett, 1976). Thus *B. decoloratus* recovered at slaughter represent ticks acquired during the previous 3 weeks compared with the multi-host tick species in which each stage, with the possible exception of males, spends approximately only 7 days on the host. Secondly the loss between the developmental stages, which do not each have to seek a new host in the case of a 1-host tick, is considerably less than that encountered with multi-host ticks. Furthermore kudus must be accepted as one of the preferred hosts of *B. decoloratus.* In the present study they harboured mean total burdens of 3 407 ticks of this species compared with 548 on blue wildebeest and 1 827 on Burchell's zebras examined in the KNP during earlier studies (Horak, De Vos & Brown, 1983; Horak *et al.,* 1984).

The overall ratio of larvae to nymphs to adults is 3,0:2,0:1,0 and this implies a good translation to adulthood without too much loss during the developmental stages and further confirms that kudus are one of the preferred hosts of *B. decoloratus.* On blue wildebeest and Burchell's zebras examined in the KNP during earlier studies these ratios were 8,9:1,7:1,0 and 3,0:1,1:1,0 respectively, indicating that wildebeest are poor hosts and zebras good hosts (Horak, De Vos & Brown, 1983; Horak *et al.,* 1984).

The ratios of males to females on the 3 host species were 1,98:1,00; 1,35:1,00 and 2,07:1,00 for the kudus, wildebeest and zebras, respectively. The most logical explanations for this disparity seem to be firstly, that because of the larger size of the females they are more easily rubbed or groomed off by the host and secondly, that the males remain attached for longer than the females. This differs markedly from the findings of Davey & Cooksey (1988) for *B. microplus* and *Boophilus annulatus* on artificially infested cattle. They recovered fewer males than females and recorded ratios of 1,00:1,36 and 1,00:1,35 males to females for the 2 tick species. They ascribed these differences to a selective mortality of males at some point in their development resulting in more females reaching the adult stage.

If one accepts that the kudus in the KNP acquired infestation on a daily basis and that female *B. decoloratus* spend 6 days on the animals, of which the last day is spent engorging before detaching (Londt & Spickett, 1976), then approximately 1/6 of all females should be engorging. This would imply that there should have been a total of 3 023 engorging females compared with the 360 actually recovered. This small number could be due to acquired resistance in the kudus as noted in the case of *Bos indicus* cross breeds of cattle and *B. microplus* (Sutherst, Maywald, Bourne, Sutherland & Stegeman, 1988). In cattle this resistance is only fully evident at approximately 2 years of age, but was already effective in the kudu calves. The small number could also be due to the fact that the kudus were usually shot after 08:00 h whereas many of the engorged females may have detached earlier.

It is probable that red-billed oxpeckers, which are commonly found on kudus in the KNP, also played a role in reducing the numbers of engorging female *B. decoloratus.* This tick is one of the preferred foods of these birds (Bezuidenhout & Stutterheim, 1980). Blue wildebeest and Burchell's zebras examined in the KNP also harboured small numbers of engorging female *B. decoloratus* compared to the total burdens of ticks of this species (Horak, De Vos & Brown, 1983; Horak *et al.,* 1984).

The peaks of abundance recorded for *B. decoloratus* on the kudus during September and October 1981 and November and December 1982 correspond to the peaks recorded during October 1978 on blue wildebeest and September 1979 and 1980 and December 1980 on Burchell's zebras in the KNP. These peaks, which occurred in spring or early summer, could be due to synchronous hatching of large numbers of larvae from eggs that had overwintered (Robertson, 1981; Spickett & Heyne, 1990). The spring rise could also possibly be coupled to a decrease in host resistance resulting from poor nutrition during the preceding winter and early spring months (Sutherst *et al.,* 1979).

Baker & Ducasse (1967) recovered peak numbers of *B. decoloratus* from calves in Natal from November to June. With the exception of 1 year when large numbers of ticks were present during November and December, Robertson (1981) recovered most *B. decoloratus* from cattle on a coastal property in the eastern Cape Province from February to June during a 4 year survey. Spickett, De Klerk, Enslin & Scholtz (1989) recorded peaks in the activity of *B. decoloratus* on cattle in the south-eastern Transvaal during February, July, October and December. In Natal Baker, Ducasse, Sutherst & Maywald (1989) recorded peak activity on cattle during spring and autumn. Rechav & Kostrzewski (1991) found peaks of activity in March/April, July, September/October, and December/January on cattle in the northern Transvaal. Horak, Williams & Van Schalkwyk (1991) recovered most *B. decoloratus* from Merino sheep during July and November in the eastern Orange Free State and in the eastern Cape Province. It would thus appear that in South Africa *B. decoloratus* may be encountered in peak numbers during any or all seasons. Nevertheless, spring and late summer seem to be the most preferred times.

The inland Valley Bushveld regions of the eastern Cape Province are not a suitable habitat for the free-living stages of *B. decoloratus.* Very few were recovered from the kudus in the AVKR and on "Bucklands" and none on the kudus from the Addo Park. Knight & Rechav (1978) also recovered only a few *B. decoloratus* from the kudus they examined on "Bucklands" and its environs.

In the KNP 21,3 % of all *B. decoloratus* were attached to the lower legs and feet of the kudus, 13,9 % to the heads and ears, 63,4 % to the necks, bodies and upper legs and 1,4 % to the tails. Only 10,9 % of the population of female ticks was attached to the legs and lower feet compared with 24,9 % of the males, indicating a selective loss of the larger female life stage from this attachment site.

Furthermore only 4,4 % of all engorging females were recovered from the lower legs and feet while 81,1 % and 6,1 % were recovered from the necks, bodies and upper legs and from the tails, respectively. This indicates that the lower legs and feet were particularly unfavourable for the completion of the female life cycle whereas the tails seemed to afford most protection for these large ticks. On Burchell's zebras examined in the park at an earlier occasion 8,0 % of *B. decoloratus* were attached to the lower legs and feet, 8,9 % to the heads and ears and 83,1 % to the necks, bodies, upper, legs and tails (Horak *et al.,* 1984).

Haemaphysalis silacea

According to Howell, Walker & Nevill (1978) this tick is found in well-wooded ravines and river valleys in the eastern Cape Province and in Natal. Hence its presence on kudus in the Valley Bushveld vegetation of the AVKR, "Bucklands" and Addo Elephant National Park. It has a wide host range including kudus, eland, sheep, goats, cattle and helmeted guineafowls (Knight & Rechav, 1978; Horak, Potgieter, Walker, De Vos & Boomker, 1983; Horak & Knight, 1986).

In the present survey 27,8 % of all males and 59,5 % of all females were found attached on the tails of the kudus in the AVKR. In addition 84,8 % of all the engorging female ticks were recovered from the tails. This need not necessarily imply that the tail

is a preferred site of attachment for female ticks of this species, but rather that the long hair on the tail affords greater protection against grooming for this larger life stage and particularly for those that are engorging.

As only 1 kudu was examined at each occasion the pattern of seasonal abundance on these animals is not reliable. It would, however, appear as if the life cycle continues throughout the year. Combining the findings of this study with those of Norval (1975a), Knight & Rechav (1978), Rechav (1982) and Horak, Williams & Van Schalkwyk (1991), larvae are most numerous from summer to early winter, nymphs from autumn to spring and adults in spring and in late summer.

***Hyalomma* spp.**

The distribution of *Hyalomma marginatum rufipes* includes the Valley Bushveld regions of the eastern Cape Province, while that of *Hyalomma truncatum* includes the latter region as well as the KNP (Howell *et al.*, 1978). Scrub hares are the preferred hosts of the immature stages of both these ticks (Horak & MacIvor, 1987; Rechav, Zeederberg & Zeller, 1987; Horak & Fourie, 1991). Using the number of ticks recovered from scrub hares as criterion the Valley Bushveld is not a good habitat for the 2 *Hyalomma* spp. (Horak & MacIvor, 1987; Horak & Fourie, 1991), whereas the KNP is a good habitat for *H. truncatum* (Horak, Spickett & Braack, unpublished data). The small number of adult ticks recovered from the kudus in the KNP is therefore evidence that these animals are not good hosts of this tick. The preferred hosts of the adults are eland and zebras and probably giraffes (Rechav *et al.*, 1987; Horak, Fourie, Novellie & Williams, 1991). The small numbers of the 2 *Hyalomma* spp. on the kudus in the eastern Cape Province are a reflection both of the unsuitability of the habitat and the host species.

Adult *H. truncatum* were generally recovered from the kudus in the KNP during any month from January to July. In the AVKR and on "Bucklands" *Hyalomma* spp. were recovered in March, April and during June.

Ixodes pilosus

In the Cape Province this tick is generally confined to the Sourveld coastal regions (Howell *et al.*, 1978). Its presence on the animals in the AVKR probably reflects its most northern distribution at this particular point. The preponderance of parasitic females over males is typical for this species (Norval, 1974b; Horak, Sheppey, Knight & Beuthin, 1986), in which mating probably takes place off the host.

Rhipicephalus appendiculatus

The KNP, AVKR and "Bucklands" all lie within the geographic distribution of this tick as described by Howell *et al.* (1978). The Addo Elephant National Park is situated to the west of the southern limits of this distribution and no *R. appendiculatus* were recovered from the kudus examined in this park.

The adults appear to prefer large bovids such as cattle, eland and buffaloes but kudus, sable antelopes and impala are also good hosts (Norval, Walker & Colborne, 1982; Horak, Potgieter, Walker, De Vos & Boomker, 1983). The immature stages can also be recovered in large numbers from these hosts, but may be encountered in similar large numbers on Burchell's zebras and on a variety of smaller animals such as sheep, goats, small antelope and scrub hares (Norval *et al.*, 1982; Horak *et al.*, 1984; Horak & Knight, 1986).

The taxonomic differences between *R. appendiculatus* and *R. zambeziensis* have only fairly recently been described (Walker, Norval & Corwin, 1981). We have always been able to distinguish between the nymphs of the 2 species and did so for each of the separate skin regions examined. The larvae and adults, however, were only differentiated once the ticks for each kudu had been pooled and hence no preferred sites of attachment for these stages can be identified. In the KNP 21,8 % of nymphs of *R. appendiculatus* were recovered from the lower legs and feet, 53,1 % from the heads and ears and 25,1 % from the necks, upper legs, bodies and tails of the kudus. These figures were 27,4 %, 50,1 % and 22,5 % respectively for the animals in the AVKR. Baker & Ducasse (1967) recovered 58,0 % of nymphs from the heads and ears of live-sampled cattle in Natal and 16,6 % from their legs and feet. In Uganda Kaiser, Sutherst & Bourne (1982) recovered 24 % of nymphs from the head and ears of live-sampled cattle and 20 % from around the hooves.

The overall ratio of larvae to nymphs to adults of 2,49:0,67:1,00 on kudus in the KNP and 8,54:1,51:1,00 in the AVKR compared with the 16:4:1 we consider closer to the normal population distribution for a 3-host tick, can have various explanations. Firstly, the recovery of the immature stages by the scrubbing method employed may not be as effective as for the larger adults. Secondly, smaller antelope species and scrub hares may carry substantial numbers of immatures with few or no adults (Horak, 1982; Boomker, Du Plessis & Boomker, 1983; Horak & Knight, 1986). Large numbers of *Rhipicephalus* spp. nymphs and probably also larvae, may selectively be removed by oxpeckers (Bezuidenhout & Stutterheim, 1980). Baker & Ducasse (1967) recorded ratios of 4,10 larvae to 2,87 nymphs to 1,00 adults on live-sampled cattle in Natal.

The ratio of males to females of 1,78:1,00 on kudus in the KNP and 1,86:1,00 in the AVKR compares favourably with that of 1,84:1,00 and 1,88:1,00 recorded by Londt, Horak & De Villiers (1979) and Horak (1982) on cattle in the northern Transvaal and of 1,99:1,00 found by Kaiser *et al.* (1982) on cattle in Uganda. The latter authors recorded a ratio of 1,84:1,00 only 7 days after the hosts had been picked clean of ticks and suggested that further experiments to explain this phenomenon were necessary. Bezuidenhout & Stutterheim (1980) found that oxpeckers consume nearly twice as many female *Rhipicephalus* spp. as they do males.

If one assumes that female *R. appendiculatus* spend approximately 7 days on their hosts

(Minshull, 1982), that these hosts are constantly exposed to infestation during periods of peak seasonal abundance of the ticks, and that the female ticks engorge during the last 24 h of their attachment, then approximately 1/7 (14,3 %) of the female ticks should be maturing. On the kudus in the KNP only 1,8 % were maturing, whereas this figure was 13,3 % for the animals in the AVKR. Minshull (1982) found that most engorged females of *R. appendiculatus* detached from artificially infested cattle between 06:00 and 08:00 h. As most of the kudus in the KNP were shot after 08:00 h many engorged female ticks could already have detached. The same argument does not apply to the animals in the AVKR, which were also shot after 08:00 h and yet harboured a large proportion of maturing females. Oxpeckers, which as mentioned previously, prefer female *Rhipicephalus* spp. ticks to males, may also be responsible for the small number of maturing ticks in the KNP. These birds were not present in the AVKR.

The seasonal abundance of the adults and nymphs in the 2 reserves was reasonably similar. In the AVKR increased numbers of larvae were recovered 1 month earlier than in the KNP, whereas peak larval activity extended for 1 month longer in the latter reserve. In general terms larvae were active from late summer to winter or spring, nymphs from winter to spring and adults from mid-summer to autumn. This pattern of abundance corresponds to that observed on cattle in Natal by Baker & Ducasse (1967), in the northern Transvaal by Horak (1982) and in the eastern Cape Province by Rechav (1982).

Short & Norval (1981) state that the pattern of seasonal abundance is chiefly dependent on the activity period of the adults and that this is regulated by the combined influences of humidity, temperature and daylength. Unfortunately too few animals were examined in each of the reserves to determine accurately the periods of activity of the adults. If, however, tick counts from cattle slaughtered at monthly intervals over a 2 year period on "Bucklands" at the same time as the kudus in the AVKR (Horak, unpublished data), are added to the latter data it would appear as if peak adult activity extends from December to February in this region of the eastern Cape Province. This corresponds exactly with that recorded by Rechav (1981) in this area. Taking the mean values for the 2 year study in the KNP into account peak adult activity occurred from February to May in this park.

Rhipicephalus evertsi evertsi

Although this tick has a very widespread distribution in South Africa (Howell *et al.*, 1978), it never occurs in very large numbers except on zebras and eland (Horak *et al.*, 1984; Horak, Fourie, Novellie & Williams, 1991). If the burdens of the kudus in the KNP are compared with those of Burchell's zebras examined a few years previously in the same park (Horak *et al.*, 1984) it is obvious that kudus are not a preferred host of *R. evertsi evertsi*. The mean burdens of the zebras comprised 606 larvae, 259 nymphs and 76 adults compared with 95 larvae, 10 nymphs and 2 adults on the kudus. In addition, it would appear as if kudus do not, or cannot, harbour many nymphs of this 2-host tick, of which the immature stages occur in the ear canal. This could affect the successful translation of larvae to nymphs when many larvae are present. In the KNP mean burdens of 95 larvae translated into only 10 nymphs compared with mean burdens of 16 larvae on kudus in the AVKR and "Bucklands" combined, translating into 11 nymphs. The largest number of nymphs recovered from a kudu was 72, compared with 626 from an eland and 1 944 from a zebra (Horak, unpublished data).

Combining the total numbers of adult *R. evertsi evertsi* recovered from all the kudus examined in the present surveys, the ratio of males to females is 2,75:1,00. The marked preponderence of males is probably because more males than females may be recovered from animals even within 1 week of them having been picked clean of ticks, and that males may remain on the host for longer than females and thus their numbers accumulate (Kaiser *et al.*, 1982).

No clear pattern of seasonal abundance was evident. The fact that both adults and immatures may be present throughout the year indicates that more than 1 life cycle can be completed annually and that development is continuous in the regions in which the present surveys were conducted. This corresponds to the observations made by Matson & Norval (1977) on cattle in Zimbabwe, Horak, Williams & Van Schalkwyk (1991) on sheep in the Orange Free State and in the eastern Cape Province, Horak *et al.* (1984) and Horak, Fourie, Novellie & Williams (1991) on Burchell's zebras in the KNP as well as on Cape mountain zebras and eland in the Karoo respectively.

Rhipicephalus glabroscutatum

The geographic distribution of this tick has been described by MacIvor (1985). It is largely confined to the eastern Cape Province where it inhabits non-coastal areas of low rainfall characterized by Karoo and Karoid vegetation, with isolated pockets extending into the western Cape Province. Its original hosts were probably the antelope inhabiting these regions and more particularly eland, kudus, mountain reedbuck and common duikers (MacIvor, 1985; Horak & Knight, 1986; MacIvor & Horak, 1987; Horak, Fourie, Novellie & Williams, 1991) and probably also bushbuck. Scrub hares may harbour the immature stages only (Horak & Knight, 1986; Horak & Fourie, 1991). With the introduction of domestic stock into these regions *R. glabroscutatum* now also infests goats, sheep and cattle (MacIvor & Horak, 1984, 1987; MacIvor, 1985; Horak & Knight, 1986; Horak, Williams & Van Schalkwyk, 1991).

According to MacIvor (1985) the preferred site of attachment is the legs and feet. In the present survey 83,9 % of all immature ticks and 95,7 % of all adults were recovered from the lower legs and feet of the kudus in the AVKR and on "Bucklands". MacIvor & Horak (1987) state that while goats may frequently harbour large numbers of adult ticks between their hooves none where found between the hooves of the antelope they examined on one of the farms on which they worked. They suggested

that this difference might be due to the structure of the hooves with the concave axial corium of the goat hoof resulting in a space in the interdigital region which could be exploited by ticks, while the straight axial corium of the antelopes' hooves limited this space.

The seasonal abundance of *R. glabroscutatum* on a variety of host species has been determined in the eastern Cape Province (Knight & Rechav, 1978; MacIvor & Horak, 1984, 1987; Horak, Williams & Van Schalkwyk, 1991; Horak, Knight & Williams, 1991; Horak & Fourie, 1991), the Karoo (Horak, Fourie, Novellie & Williams, 1991) and the south-western Cape Province (Horak, Sheppey, Knight & Beuthin, 1986). In all these regions the greatest numbers of immature ticks were recovered from March to August and of adults from September to January or February. It is probable that only 1 generation is completed annually (MacIvor, 1985).

Rhipicephalus* sp. (near *R. oculatus)

The taxonomic problems that exist between this tick and *Rhipicephalus oculatus* have been discussed by Walker (1991). Its geographic distribution has also been briefly addressed by Walker (1991). It is fairly common in certain Valley Bushveld regions of the eastern Cape Province, where the adults may be found on scrub hares, kudus, cattle, sheep and goats (Horak & Knight, 1986).

In the present study 10,6 % of the ticks were recovered from the heads and ears of the kudus, 80,8 % from the necks, bodies and upper legs, and equal proportions from the lower legs plus feet and from the tails. May and June appear to be the only months in which no adult ticks are present. This pattern of seasonal abundance was confirmed on scrub hares, sheep, goats and cattle examined in the AVKR or on "Bucklands" at the same time as the kudus (Horak, unpublished data).

Rhipicephalus simus

Although this tick has a widespread distribution, mainly in the eastern regions of South Africa (Howell *et al.*, 1978), it is seldom encountered in large numbers. The preferred hosts of the adults are large monogastric animals such as zebras, warthogs, large wild carnivores and dogs, but they also occur on cattle (Howell *et al.*, 1978; Horak *et al.*, 1984; Horak, Jacot Guillarmod, Moolman & De Vos, 1987; Horak *et al.*, 1988).

In the KNP a total of 15 adults were recovered from the 95 kudus examined, while 33 Burchell's zebras, 7 large carnivores and 51 warthogs examined in the park harboured totals of 381, 669 and 560 adults respectively (Horak *et al.*, 1984; Horak Jacot Guillarmod, Moolman & De Vos, 1987; Horak *et al.*, 1988). The 25 kudus shot in the AVKR and on "Bucklands" harboured a total of only 6 adults while 46 cattle examined on "Bucklands" at the same time harboured 48 adults (Horak, unpublished data). It is thus obvious that kudus are not good hosts of adult *R. simus*. The immature stages prefer rodents (Norval & Mason, 1981).

Twelve of the 15 ticks recovered from the kudus in the KNP and all 6 ticks from the kudus in the AVKR were collected from the lower legs and feet of the animals. Too few ticks were present to determine any pattern of seasonal abundance.

Rhipicephalus zambeziensis

This tick has only fairly recently been described and its morphology compared with that of *R. appendiculatus* (Walker *et al.*, 1981). Its ecology and that of *R. appendiculatus,* with particular emphasis on Zimbabwe, have also been described (Norval *et al.*, 1982). In South Africa *R. zambeziensis* has to date only been found in the Transvaal and more particularly on farms in the west of the province as well as in the northern and southern regions of the KNP in the east of the province (Norval *et al.*, 1982). This distribution falls entirely within that of *R. appendiculatus* as illustrated by Howell *et al.* (1978). However, more recent data from the KNP indicate that there are areas of overlap as well as regions in which one or the other tick occurs almost exclusively (Horak, Spickett & Braack, unpublished data). The study site from which the kudus in the KNP were collected lies within such a region of overlap. To the east and west of this site there are zones within the KNP in which *R. appei diculatus* occurs almost exclusively and to the north a zone in which *R. zambeziensis* occurs virtually exclusively (Horak, Spickett & Braack, unpublished data).

Although large carnivores, warthogs, bushpigs and equids can be infested, the preferred hosts of *R. zambeziensis* seem to be impala, bushbuck, nyalas, kudus, eland and probably cattle and buffaloes (Norval *et al.*, 1982; Walker, 1991). In the present study 91 of the 95 kudus were infested. Two of the 4 kudus that were not infested were examined during November and 1 during December, both months of generally low abundance for all stages of development (Fig. 1). The total numbers of *R. appendiculatus* and *R. zambeziensis* recovered from the kudus suggest that the zone in which they were examined is equally favourable for both tick species.

As mentioned earlier for *R. appendiculatus*, we can unfortunately also only give the preferred sites of attachment for the nymphal stage of *R. zambeziensis*. Of these 81,4 % were attached to the lower legs and feet, 9,2 % to the head and ears, 8,6 % to the neck, body and upper legs and 0,8 % to the tail. Thus the nymphs of *R. appendiculatus* prefer the heads and ears and those of *R. zambeziensis* the lower legs and feet of kudus.

The ratio of larvae to nymphs to adults of 9,92:1,42:1,00 indicates that the kudus are good hosts of larvae, while many nymphs possibly fed on other host species. The total numbers of larvae of *R. appendiculatus* and *R. zambeziensis* recovered from the kudus were reasonably similar but fewer nymphs and adults of *R. zambeziensis* were recovered. This suggests that kudus may be less favoured as hosts of these stages than for those of *R. appendiculatus.*

The ratio of male to female *R. zambeziensis* of 1,99:1,00 is comparable to that of *R. appendiculatus* on the same animals. As in the case of the latter tick, few maturing females were recovered.

According to Norval *et al.* (1982) the seasonal abundances of these 2 ticks are similar in Zimbabwe. The present results confirm this finding and the periods of seasonal activity are almost identical; larvae exhibiting peak abundance in autumn and winter, nymphs during winter and spring and adults in late summer.

Lice

Damalinia sp. have not previously been recovered from kudus, while *Haematopinus taurotragi* and *Linognathus taurotragus,* which were both originally described from eland, have (Ledger, 1980). The lice infestations were always light and no pattern of seasonal abundance or host age-preference or host sex-preference could be determined.

Flies

The majority of kudus at each survey locality were infested with the louse fly *Lipoptena paradoxa.* The seasonal abundance of this fly on the kudus and other aspects of its biology will be reported separately.

Pentastomid nymphs

In earlier surveys Horak, De Vos & Brown (1983) and Horak *et al.* (1988) recovered the nymphs of *Linguatula nuttalli* from 12 (21,8 %) of 55 blue wildebeest and 18 (35,3 %) of 51 warthogs examined in the KNP. Kudus would appear to be more susceptible to infection as 60 (63,2 %) of the 95 animals examined in the park were infected. Lions are the final host of this parasite.

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