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DRAG-SAMPLING OF FREE-LIVING IXODID TICKS IN THE KRUGER NATIONAL PARK

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ABSTRACT

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Free-living ticks were collected by means of drag-sampling in 32 of the 35 landscape zones of the Kruger National Park during a period of 1 calendar month. Of the 18 199 specimens collected, 99,53 % were larvae, 0,05 % nymphs and 0,42 % adults. Fourteen species were collected. *Amblyomma hebraeum* followed by *Boophilus decoloratus*, predominated, both in distribution and abundance.

Large variations were encountered between drags. There was no correlation between the numbers of larvae collected and time of day, temperature, grass length, vegetation biomass estimates and subzone type.

INTRODUCTION

The seasonal abundance of ixodid ticks on blue wildebeest, Burchell's zebras, warthogs, and impala and kudu, in the Kruger National Park (KNP) has already been determined (Horak, De Vos & Brown, 1983; Horak, De Vos & De Klerk, 1984; Horak, Boomker, De Vos & Potgieter, 1988; Horak, Boomker & De Vos, unpublished data). Incidental collections of ticks have also been made from bushbuck, nyala, eland, giraffe and several carnivore species in the KNP (Horak, Potgieter, Walker, De Vos & Boomker, 1983; Horak, Jacot Guillarmod, Moolman & De Vos, 1987). These findings are incomplete without data on the free-living ticks potentially available on the vegetation in the KNP. Such data would contribute to an understanding of tick bionomics under conditions with minimal human interference.

The KNP, which is 1 945 528 ha in extent, has been divided by Gertenbach (1983) into 35 landscape zones on the basis of geomorphology, climate, soil and vegetation patterns. These landscape zones are intended to be used as funtional management units (Gertenbach, 1983). This papter reports on a survey of free-living ticks conducted in 32 of the 35 landscape zones over a period of 1 calendar month.

MATERIALS AND METHODS

The survey was conducted during March, 1988. The collection method chosen was drag-sampling, as a means of recovering immature ticks questing on vegetation (Zimmerman & Garris, 1985; Petney & Horak, 1987).

Ten 1 000 × 100 mm flannel strips were attached adjacently with Velcro[1] tape to a 1 200 mm-long wooden spar. Each collection was made by an operator pulling this spar, by means of a twine harness attached to its ends, for a distance of 250 m over the vegetation. At the end of each drag the flannel strips were individually detached from the bar and the ticks were removed with fine-point forceps, placed in vials containing 70 % alcohol and later identified and counted. Drags were not done over dew-laden grass early in the morning or over grass after rain, as this wet the flannel strips and decreased their efficacy. A total of 345 drags were done in 32 of the 35 landscape zones defined by Gertenbach (1983). These zones have generally been numbered from the south to the north in the KNP.

Each of the landscape zones was considered as a functional unit. Geographically extensive zones were, however, divided into north and south sectors which were treated as individual zones. Zone 23 was divided into 3 portions representative of the dominant grass type present in each, i.e. *Setaria, Themeda* and *Bothriochloa*. Within each zone, 3 drags were performed in each of 3 representative subzones: open grassland, gully and woodland.

Because of logistical problems and their small size, zones 20, 26 and 27 were not sampled.

The time at which each drag was done as well as the temperature in the shade at ground level (measured with a maximum/minimum thermometer), were recorded throughout the survey. Other factors noted on a subjective scale at the time of each drag were cloud cover, grasscover, condition and average length of the grass and the game density. In addition, grass fuel loads were estimated with a disc pasture meter accoring to the method of Trollope & Potgieter (1986). The mean of 100 disc meter readings were extrapolated to an estimated fuel load in kg/ha, as an indication of the biomass of the grass sward in the particular subzone in which drags were done.

Because of the overdispersed nature of free-living ticks, all counts were logarithmically transformed [$\log_{10}(x+1)$] for statistical analyses (Petney, Van Ark & Spickett, 1990). Analyses were done only with counts of $\log_{10}(x+1) > 1$, and these were realized with only 2 species, *Amblyomma hebraeum* and *Boophilus decoloratus*. The numbers of the other tick species collected per subzone were considered too low for valid analysis.

RESULTS AND DISCUSSION

Tick species collected

A total of 14 tick species was collected. The greatest number of species recovered from any one zone was 7 (Zone 2) (Table 1). *A. hebraeum* predominated in most zones, being present in all but the northern sector of zone 32, where no ticks were recovered (Table 2). Despite being absent from 7 of the zones surveyed (Table 1), *B. decoloratus* was the next most abundant species (Table 3), and in zones

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TABLE 1 Tick species and stages collected in the different landscape zones of the Kruger National Park (zones 1–9)

Landscape zones*	Tick species													
	Amblyomma hebraeum	*Amblyomma marmoreum*	*Amblyomma nuttalli*	*Boophilus decoloratus*	*Dermacentor rhinocerinus*	*Haemaphysalis leachi*	*Hyalomma marginatum turanicum*	*Rhipicephalus appendiculatus*	*Rhipicephalus evertsi evertsi*	*Rhipicephalus* sp. (near *R. punctatus*)	*Rhipicephalus simus*	*Rhipicephalus tricuspis*	*Rhipicephalus turanicus*	*Rhipicephalus zambeziensis*
1	L			L		A		N/A			A			A
2	L	L		L		A		A	L		A			
3	L	L		L										
4	L			L/A		A			L		A			
5	L										A			
6	L			L										
7	L			L						L				
8	L			L			A	L		L				
9	L			L					L					
10	L													
11	L			L						L				
12	L			L					L	L				
13	L	L		L	L						A			
14	L							L						
15	L					A				L	A			A
16	L									L				
17S	L	L		L		A			L		A			
17N	L			L										
18	L			L										A
19N	L	L		L		A			L		A			
19S	L/N		L	L		A		N	L		A			A
21	L			L						L				
22N	L			L/N										
22S	L			L										
23Se	L								L					
23B	L			L						L			A	
23T	L									L				A
24	L			L										
25	L			L						L	A			
28	L			L				N		L	L			
29S	L	L		L				A	L					
29N	L	L		L										
30	L			L				L		L				
31				L					L		L			
32	L									L		A		
33	L	L		L					L	L				
34	L	L		L					L					
35	L									L	A			

* Zones numbered according to Gertenbach (1983)
L=Larvae; N=Nymphs; A=Adults

19 North, 22 South and 31 predominated over *A. hebraeum*. In the presence of *A. hebraeum* and the absence of *B. decoloratus*, a *Rhipicephalus* sp. (near *R. punctatus*) was predominant in zones 35 and 16 and *Rhipicephalus evertsi evertsi* in zone 23 (*Setaria*).

Of the 18 199 specimens collected, 99,53 % were larvae, 0,05 % nymphs and 0,42 % adults. Most species were represented by larvae, as the sampling method used favours this stage of development (Zimmerman & Garris, 1985; Norval, Yunker & Butler, 1987). However, several adults of *Haemaphysalis leachi, Rhipicephalus appendiculatus, Rhipicephalus zambeziensis* and *Rhipicephalus simus* and 1 adult specimen each of *B. decoloratus, Rhipicephalus tricuspis* and *Hyalomma marginatum turanicum* were collected (Table 1, Table 3). The latter tick normally occurs in the Karoo (Howell, Walker & Nevill, 1978) and its presence in the KNP is probably due to an engorged nymph detaching from a migratory bird. The recovery of an adult male *B. decoloratus* from the vegetation confirms the collection by Wilkinson (1964) cited by Mason & Norval (1981) of *Boophilus* males from drag samples. These one-host ticks probably actively quest for a new host after detachment from the original host.

Two nymphs of *A. hebraeum*, 1 nymph of *B. decoloratus* and on 3 occasions, nymphs of *R. appendiculatus* attached to the flannel strips (Table 1, Table 3). The low incidence or complete absence of *R. appendiculatus* and *R. zambeziensis* larvae on the strips is attributable to seasonality (Short & Norval, 1981; Norval, Walker & Colborne, 1982). That of *H. leachi* and *R. simus* is ascribed to the questing behaviour of the immature stages, which favours contact with rodents rather than with large mammals (Howell *et al.*, 1978).

TABLE 2 The total numbers of ixodid ticks, mean numbers of larvae per drag, number of species and the predominant species per vegetation zone collected in the Kruger National Park

Zone	Number of drags	Total larvae	Mean larvae per drag	Total nymphs	Total adults	Number of species present	Predominant species
2	9	2 555	283,89	1	4	7	A.h.
17S	9	1 785	198,33	0	3	6	A.h.
17N	9	1 771	196,78	0	0	2	A.h.
4	9	1 293	143,67	0	10	5	A.h.
33	9	1 181	131,22	0	0	5	A.h.
*15	9	1 162	129,11	0	12	5	A.h.
29N	9	960	106,67	0	0	3	A.h.
12	9	785	87,22	0	0	4	A.h.
30	8	551	68,88	0	0	4	A.h.
1	9	559	62,11	3	29	6	A.h.
18	9	555	61,67	0	1	3	A.h.
19N	9	535	59,44	2	7	7	B.d.
*23T	9	523	58,11	0	1	2	A.h.
29S	9	430	47,78	0	4	5	A.h.
8	9	396	44,00	0	0	4	A.h.
6	9	381	42,33	0	0	2	A.h.
13	9	375	41,67	0	0	3	A.h.
*14	9	365	40,56	0	0	2	A.h.
22S	9	342	38,00	0	0	2	B.d.
22N	9	274	30,44	1	0	2	A.h.
19S	9	210	23,33	0	2	6	A.h.
3	9	189	21,00	1	0	5	A.h.
21	9	188	20,89	0	0	3	A.h.
28	10	195	19,50	0	0	3	A.h.
34	9	158	17,56	0	0	4	A.h.
*5	9	81	9,00	0	1	2	A.h.
11	9	72	8,00	0	0	3	A.h.
7	9	62	6,89	0	1	4	A.h.
*35	9	49	5,44	0	0	3	R.p.
25	9	38	4,22	0	1	4	A.h.
9	9	35	3,89	0	0	3	A.h.
24	9	24	2,67	0	0	2	A.h.
31	9	15	1,67	0	0	3	B.d.
23B	9	10	1,11	0	0	3	A.h.
*10	9	6	0,67	0	0	1	A.h.
*23Se	9	3	0,33	0	0	2	R.e.
*16	9	3	0,33	0	0	2	R.p.
*32S	6	2	0,33	0	0	1	A.h.
*†32N	6	0	0	0	0	0	

S =South; N = North; Se = *Setaria;* B = *Bothriochloa;* T = *Themeda*;
B.d. = *B. decoloratus;* R.p. =*Rhipicephalus* sp. (near *R. punctatus*);
R.e. =*R. e. evertsi;* A.h. = *A. hebraeum;** = *B. decoloratus* absent; † = *A. hebraeum* absent

TABLE 3 Numbers of larvae, nymphs and adults of the 9 main tick species collected from the vegetation in the Kruger National Park

Tick species	Total number of larvae	Mean number of larvae	Total number of nymphs	Total number of adults
Amblyomma hebraeum	15669	45,42	2	0
Boophilus decoloratus	1787	5,18	1	1
Rhipicephalus sp. (near *R. punctatus*)	301	0,87	0	0
Amblyomma marmoreum	263	0,76	0	0
Rhipicephalus evertsi evertsi	73	0,21	0	0
Rhipicephalus simus	15	0,04	0	27
Rhipicephalus appendiculatus	5	0,01	5	16
Haemaphysalis leachi	1	0,00	0	18
Rhipicephalus zambeziensis	0	0,00	0	15

Although the immature stages of *Hyalomma truncatum* do occur in the KNP in large numbers on scrub hares (Horak & Spickett, unpublished data) and adults on giraffes (Horak *et al.*, 1983), no *Hyalomma* spp. larvae were recovered. Rechav (1986), using a similar collection method, obtained small numbers of larvae of both *Hyalomma truncatum* and *Hyalomma marginatum rufipes* in a bush habitat in the western Transvaal. He gives no data on grass length, however, and this may affect larval attachment to the flannel strips. They are more likely to be collected from very short grass because they prefer rodents, hares and ground-feeding birds as hosts (Rechav, 1986; Horak & MacIvor, 1987). Only 1 larva of *Dermacentor rhinocerinus* and 1 of *Amblyomma nuttali* were collected (Table 1).

Time of day

The presence of heavy dew on the grass in the early mornings precluded most drags before 09:00 as the flannel strips became too wet. Most larvae were collected between 11:00 and 12:00 and fewest between 16:00 and 17:00 (Fig. 1). No drags were performed after 17:00. To determine whether there were significant differences in the numbers of larvae collected at different times of the day, it was assumed that equal numbers would be collected irrespective of the time of day. To accommodate contagious distribution the means per drag for each time interval were transformed, indexed [$\log_{10}$ (mean/drag) × 10] and used as observed frequencies. The overall mean of the observed values was transformed and indexed [$\log_{10}$ (mean) × 10] to serve as expected frequencies. Chi-squared analysis of these observations, however, showed no significant difference (P=0,05) between the larval numbers collected at different times of the day.

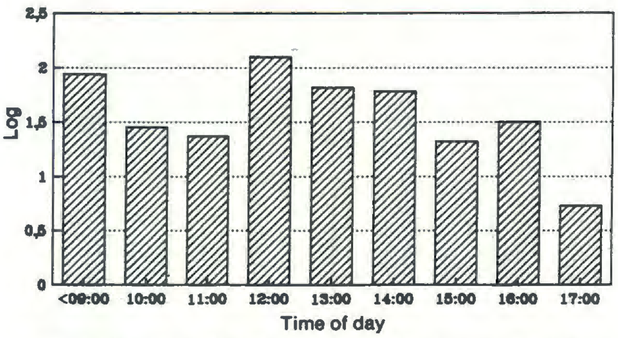

FIG. 1 Mean number [$\log_{10}$ (x+1)] of tick larvae collected per drag at various times of the day in different landscape zones of the Kruger National Park

These results are in contrast to those of Rechav (1979), who found more than 80 % of larvae of *A. hebraeum* (which constitute the majority of larvae collected in this survey), *R. appendiculatus* and *R. evertsi evertsi* on grass tips and 20 % on the ground at 06:00 and 09:00. He found only 50 % on grass tips at 12:00 and an 'increased number' towards evening, at a locality in the eastern Cape Province of South Africa.

Temperature

Temperature in the shade at ground level ranged from 25 °C–37 °C, while the numbers of *A. hebraeum* larvae collected [$\log_{10}$ (x+1)] ranged from 0–3,218, and those of *B. decoloratus* from 0–1,838. Neither the total numbers of larvae collected nor the numbers of *A. hebraeum* (Fig. 2) and *B. decoloratus* were temperature-dependant at the time of collection within the temperature range recorded. This probably indicates that the larvae of all species are active over the complete temperature range measured.

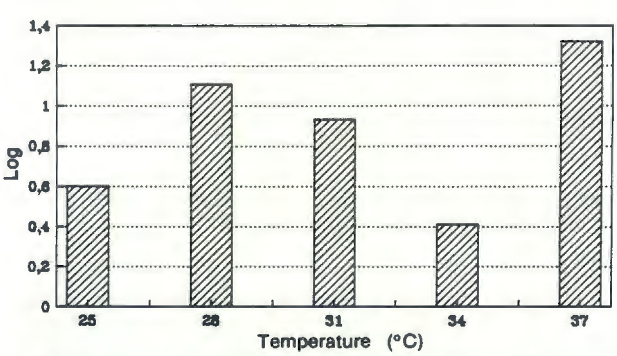

FIG. 2 Mean number [$\log_{10}$ (x+1)] of *Amblyomma hebraeum* larvae collected by drag-sampling at various temperatures in different landscape zones of the Kruger National Park

Vegetation biomass

Of the 62 observations where the numbers of *A. hebraeum* larvae [$\log_{10}$ (x+1)] ranged from 1–3,218 (SD=0,605), the corresponding biomass estimations ranged from 608–7541 kg/ha (SD=1403,442). There was a poor relationship between the numbers of larvae recovered and the biomass estimations, with a coefficient of correlation of r = 0,0425 for *A. hebraeum*.

Grass length

In laboratory experiments Londt & Whitehead (1972) found that *A. hebraeum* larvae prefer an 'optimal vegetation height' of 380 mm. In this study *A. hebraeum* larvae, ranging in numbers from 1–3,023, showed no significant correlation at 5 % (r = 0,0854) with the mean estimated length of the grass from which they were collected, which ranged from 250–1 000 mm (Fig. 3). *B. decoloratus* larvae, ranging in number from 1,041–2,702, also showed no significant correlation at 5 % (r = 0,3646) with the same range of grass lengths. However, most *B. decoloratus* larvae were collected from grass with a mean estimated length of between 700 and 900 mm (Fig. 4). Londt & Whitehead (1972) consider the 'optimal vegetation height' for this species to be 200 mm.

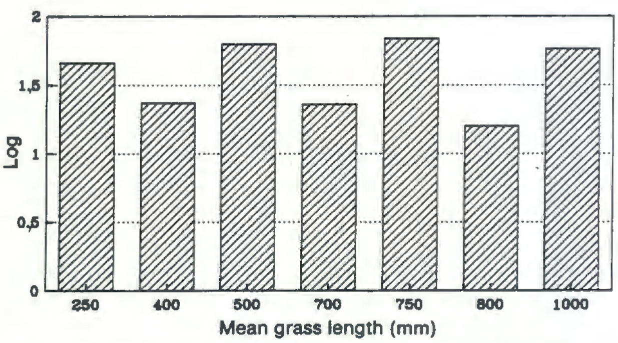

FIG. 3 Mean number [$\log_{10}$ (x+1)] of *Amblyomma hebraeum* larvae collected by drag-sampling from grass of various lengths in different landscape zones of the Kruger National Park

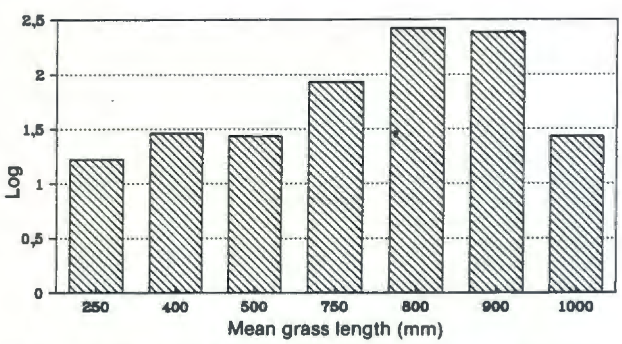

FIG. 4 Mean number [$\log_{10}$ (x+1)] of *Boophilus decoloratus* larvae collected by drag-sampling from grass of various lengths in different landscape zones of the Kruger National Park

Subzones

The mean numbers of *A. hebraeum* larvae collected were consistently greater than those of *B. decoloratus* in all 3 subzones when both species were present (Fig. 5). However, neither species occurred significantly more frequently than the other in any of the 3 subzones (chi-squared= 0,412 , $P < 0,05$).

In open grassland the numbers of *A. hebraeum* larvae collected ranged from 0,301–2,534, in gullies from 0,602–3,072, while woodland subzones yielded the highest numbers (0,301–3,146). *A. hebraeum* is commonly regarded as a species that is ecologically dependent on tall grass and tree shade (Theiler, 1948; Londt & Whitehead, 1972; Norval, 1974), and substitution of bush with kikuyu grass pasture has been suggested as a method of reducing populations of this species (Spickett, 1987). Multiple comparison of means by the Bonferroni method, however, showed no significant differences between the numbers of larvae collected in the 3 subzones in this survey.

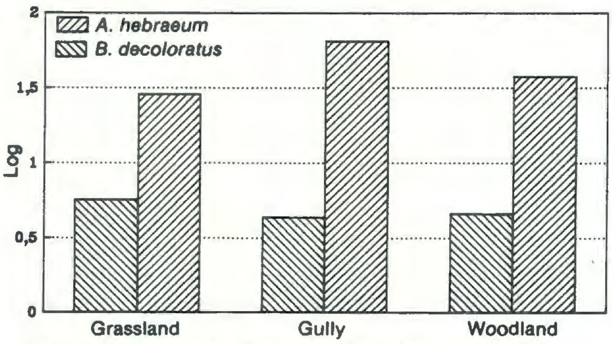

FIG. 5 Mean number [$\log_{10}(x+1)$] of *Amblyomma hebraeum* and *Boophilus decoloratus* larvae collected by drag-sampling from 3 subzones within different landscape zones of the Kruger National Park

Corresponding ranges for *B. decoloratus* were open grassland 0,477–2,709; gullies 0,602–1,954, and woodland subzones 0,301–1,954 larvae. According to Londt & Whitehead (1972), *B. decoloratus* prefers protected vegetation (sheltered by neighbouring trees and bushes), as opposed to covered vegetation (under a complete canopy of trees) and open vegetation (not in the immediate vicinity of trees). Although open grassland yielded more larvae of this species than the other subzones, no significant differences in the numbers recovered from the 3 subzones could be demonstrated.

The vast variation in the vegetation typifying the different landscape zones would tend to obviate any experimental assumption of subzone homogeneity. A typical grassland subzone in a thicket landscape could resemble a typical woodland in a savanna landscape. The low numbers of larvae recovered, high variation between drags and the small number of drags performed per subzone, prevented valid analyses within individual landscapes.

To test whether the absence of any association between the 2 predominant tick species and any of the 3 subzones was due to incorrect experimental assumption, similar landscape zones were grouped to form larger vegetational zones. This attempt to increase the number of drags per subzone, while at the same time improving subzone homogeneity, provided no evidence of statistical correlation between the total number of larvae collected, or the numbers of *A. hebraeum* or of *B. decoloratus* larvae recovered and open grassland, woodland or gully subzones.

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