Parasites of domestic and wild animals in South Africa. XXXVIII. Ixodid ticks collected from 23 wild carnivore species

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ABSTRACT

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Ixodid ticks were collected from 104 wild carnivores belonging to 23 species in various nature reserves and on several farms in all nine provinces of South Africa. Seven feral cats in a nature reserve were also examined. Twenty-four tick species belonging to seven genera were recovered and identified. Amongst these ticks we consider the adults of *Haemaphysalis leachi*, *Haemaphysalis spinulosa*, *Haemaphysalis zumpti*, *Ixodes rubicundus*, *Rhipicentor nuttalli*, *Rhipicephalus simus* and *Rhipicephalus turanicus* to be true parasites of wild carnivores. Although numerous adult *Rhipicephalus appendiculatus* and *Rhipicephalus zambeziensis* were collected from some lions these were either sick or old animals. The immature stages of seven species regularly utilized wild carnivores as hosts on an opportunistic basis.

Keywords: Ixodid ticks, South Africa, wild carnivores

INTRODUCTION

Many ixodid tick species have been recorded from wild carnivores in Africa, but few actually prefer these animals as hosts. Theiler (1962) records 19 species in the sub-Saharan region as frequently present on wild carnivores, while in a review of the 77 ixodid tick species occurring in South Africa Walker (1991) considers that 20 are often present on these animals. Norval & Mason (1981), Norval (1984; 1985) and Norval & Colborne (1985) list five species as preferring carnivores in Zimbabwe. Walker, Keirans & Horak (2000) document 43 species of rhipicephalids that have been recorded from wild carnivores in Africa, of which they consider seven species to be true parasites of these animals.

In South Africa *Haemaphysalis leachi*, *Rhipicentor nuttalli*, *Rhipicephalus simus* and *Rhipicephalus turanicus* are parasites of the larger wild carnivores, whereas *Haemaphysalis spinulosa*, *Haemaphysalis zumpti*, *Ixodes rubicundus*, ticks of the *Ixodes pilosus* group and *Rhipicephalus theileri* prefer the smaller species (Stampa 1959; Hoogstraal & El Kammah 1974; Horak, Jacot Guillarmod, Moolman & De Vos 1987b; Walker 1991; Horak, Chaparro, Beaucournu & Louw 1999). Records of *Rhipicephalus sanguineus* from wild carnivores probably refer to *R. turanicus*, with which it has often been confused in the past (Pegram, Clifford, Walker & Keirans 1987; Walker *et al.* 2000).

The present paper records the ixodid tick species collected from various wild carnivore species in several habitats in South Africa.

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MATERIALS AND METHODS

Wild carnivores in the Kruger National Park, South Africa are from time to time killed in fights, or in road accidents, or are shot because they have become nuisance animals, or because they are severely injured or ill. Provided the carcasses of these animals were obtained shortly after death they were considered suitable for tick recovery. At various other localities in South Africa wild carnivores were shot because they were considered nuisance animals or specifically for various survey purposes. In the Kruger National Park and in the Free State Province the carcasses of most of the larger carnivores were processed for tick recovery as described by Horak, Boomker, Spickett & De Vos (1992) for greater kudus (*Tragelaphus strepsiceros*). Those of the smaller animals in this park and in the Free State as well as some of those in the Northern Cape Province were treated as described for scrub hares (*Lepus saxatilis*) by Horak, Sheppey, Knight & Beuthin (1986) and Horak & Fourie (1991). Ticks were collected from other animals in a similar fashion, or collected manually from dead or chemically-immobilized carnivores. All the ticks collected were identified and counted under a stereoscopic microscope.

These collections have proceeded from the 1970s until 2000 at which time we considered that there were sufficient data to warrant publication. The scientific nomenclature that we have used for the wild carnivore hosts is based on that suggested by Wilson & Reeder (1993), and where practicable we have treated or listed these animals in the same sequence as that given by these authors. The animals and the localities at which they were sampled are summarized in Table 1.

RESULTS AND DISCUSSION

The numbers of ticks collected from wild carnivores in the Kruger National Park, in nearby provincial nature reserves in Mpumalanga Province, in the Madikwe Nature Reserve, North West Province, and in the Hluhluwe and Umfolozi Game Reserve and on a private game farm in north-eastern KwaZulu-Natal are summarized in Tables 2–14.

Thirteen species of wild carnivores, of which the majority were lions, were examined at these localities. Seven feral cats were also examined in the Kruger National Park. Seventeen ixodid tick species were identified to species level on these animals.

The ticks collected from wild carnivores in the provinces of Gauteng, Free State, Northern, Western and Eastern Cape are summarized in Tables 15–19.

TABLE 1 Carnivores and the localities at which they were examined for ixodid ticks

Carnivore species		Number examined	Province or locality
Common name	Scientific name		
Black-backed jackal	*Canis mesomelas*	5	KNP; central Free State; north-western Northern Cape; Eastern Cape
Hunting dog	*Lycaon pictus*	6	KNP; North West Province
Bat-eared fox	*Otocyon megalotis*	2	South-western Free State
Cape fox	*Vulpes chama*	3	South-western Free State; Eastern Cape
Cheetah	*Acinonyx jubatus*	3	KNP
Caracal	*Caracal caracal*	2	South-western Free State; north-western Northern Cape
African wild cat	*Felis lybica*	3	KNP; south-western Free State; north-western Northern Cape
Feral cats	*Felis catus*	7	KNP
Lion	*Panthera leo*	23	KNP; north-eastern KwaZulu-Natal
Leopard	*Panthera pardus*	5	KNP; Gauteng
Yellow mongoose	*Cynictis penicillata*	1	Eastern Cape
Slender mongoose	*Galerella sanguinea*	2	KNP; north-eastern Mpumalanga
Small grey mongoose	*Galerella pulverulenta*	3	North-western Northern Cape; Eastern Cape
White-tailed mongoose	*Ichneumia albicauda*	2	KNP
Banded mongoose	*Mungos mungo*	2	KNP
Meercat	*Suricata suricatta*	1	North-western Northern Cape
Spotted hyaena	*Crocuta crocuta*	9	KNP; north-eastern KwaZulu-Natal
Brown hyaena	*Parahyaena brunnea*	1	Gauteng
Aardwolf	*Proteles cristatus*	2	South-western Free State; Eastern Cape
Ratel (Honey badger)	*Mellivora capensis*	9	KNP, northern Northern Cape, Western Cape
Zorilla	*Ictonyx striatus*	2	South-western Free State; Eastern Cape
Civet cat	*Civettictis civetta*	6	KNP; north-eastern Mpumalanga
Small-spotted genet	*Genetta genetta*	1	Eastern Cape
Large-spotted genet	*Genetta tigrina*	8	KNP; north-eastern Mpumalanga
"Genet"	*Genetta* sp.	3	Eastern Cape

KNP = Kruger National Park

TABLE 2 Ixodid ticks collected from a black-backed jackal in the Kruger National Park

Tick species	Number of ticks collected				
	Larvae	Nymphs	Males	Females	Total
Amblyomma hebraeum	15	100	0	0	115
Amblyomma marmoreum	183	21	0	0	204
Haemaphysalis leachi	0	0	3	1	4
Rhipicephalus evertsi evertsi	2	0	0	0	2
Rhipicephalus simus	13	0	0	0	13
Rhipicephalus zambeziensis	193	35	1	1	230

TABLE 3 Ixodid ticks collected from six hunting dogs, two in the Kruger National Park and four in the Madikwe Nature Reserve, North West Province

Tick species	Number of ticks collected					No. of dogs infested
	Larvae	Nymphs	Males	Females	Total	
Amblyomma hebraeum	2	14	0	0	16	2
Rhipicephalus simus	2	0	18	6	26	6
Rhipicephalus turanicus	0	0	0	2	2	2
Rhipicephalus zambeziensis	47	3	0	1	51	3

TABLE 4 Ixodid ticks collected from three cheetahs in the Kruger National Park

Tick species	No. of ticks collected					No. of cheetahs infested
	Larvae	Nymphs	Males	Females	Total	
Amblyomma hebraeum	23 960	1 301	15	0	25 276	3
Amblyomma marmoreum	26	18	0	0	44	2
Boophilus decoloratus	5	0	0	0	5	2
Haemaphysalis leachi/zumpti	1	0	–	–	1	1
Haemaphysalis leachi	–	–	159	34	193	3
Haemaphysalis zumpti	–	–	9	0	9	1
Hyalomma truncatum	0	0	1	0	1	1
Rhipicephalus appendiculatus	667	78	23	2	770	3
Rhipicephalus evertsi evertsi	14	0	1	0	15	3
Rhipicephalus simus	10	0	292	46	348	2
Rhipicephalus turanicus	0	0	2	6	8	1
Rhipicephalus zambeziensis	65	10	10	3	88	3

TABLE 5 Ixodid ticks collected from an African wild cat and seven feral cats in the Kruger National Park

Tick species	Number of ticks collected					No. of cats infested
	Larvae	Nymphs	Males	Females	Total	
Amblyomma hebraeum	32	8	0	0	40	7
Amblyomma marmoreum	60	1	0	0	61	6
Haemaphysalis leachi/zumpti	72	90	–	–	162	6
Haemaphysalis leachi	–	–	2	3	5	4
Haemaphysalis zumpti	–	–	32	18	50	6
Rhipicephalus simus	0	1	0	0	1	1
Rhipicephalus turanicus	0	0	0	2	2	1
Rhipicephalus zambeziensis	4	7	0	0	11	3

TABLE 6 Ixodid ticks collected from 22 lions in the Kruger National Park and from one in the Hluhluwe and Umfolozi Game Reserve in north-eastern KwaZulu-Natal

Tick species	Number of ticks collected					No. of lions infested
	Larvae	Nymphs	Males	Females	Total	
Amblyomma hebraeum	15 852	3 396	277	49	19 574	22
Amblyomma marmoreum	43	203	0	0	246	16
Amblyomma tholloni	0	2	0	0	2	1
Boophilus decoloratus	5	0	8	1	14	7
Haemaphysalis leachi/zumpti	2	2	–	–	4	3
Haemaphysalis leachi	–	–	2 198	831	3 029	19
Haemaphysalis zumpti	–	–	65	31	96	17
Hyalomma truncatum	1	2	2	0	5	3
Ixodes sp.	0	4	0	2	6	1
Rhipicephalus appendiculatus	96	230	1 835	804	2 965	21
Rhipicephalus evertsi evertsi	38	0	2	0	40	7
Rhipicephalus simus	3	6	968	603	1 580	17
Rhipicephalus turanicus	0	0	5	5	10	3
Rhipicephalus zambeziensis	39	20	3 343	1 481	4 883	19

TABLE 7 Ixodid ticks collected from four leopards in the Kruger National Park

Tick species	Number of ticks collected					No. of leopards infested
	Larvae	Nymphs	Males	Females	Total	
Amblyomma hebraeum	1 728	93	1	0	1 822	4
Amblyomma marmoreum	43	10	0	0	53	4
Haemaphysalis leachi/zumpti	16	1	–	–	17	2
Haemaphysalis leachi	–	–	63	26	89	3
Haemaphysalis zumpti	–	–	48	13	61	4
Rhipicephalus appendiculatus	1	0	56	8	65	3
Rhipicephalus simus	0	0	20	12	32	2
Rhipicephalus turanicus	0	0	0	2	2	1
Rhipicephalus zambeziensis	0	0	31	13	44	3

TABLE 8 Ixodid ticks collected from a slender mongoose in the Kruger National Park and from one in the Mthethomusha Nature Reserve, Mpumalanga Province

Tick species	Number of ticks collected					No. of mongooses infested
	Larvae	Nymphs	Males	Females	Total	
Haemaphysalis spinulosa	0	0	3	1	4	1
Haemaphysalis zumpti	0	0	6	4	10	1
Ixodes sp.	0	1	0	0	1	1
Rhipicephalus appendiculatus	1	6	0	0	7	1
Rhipicephalus zambeziensis	27	173	0	0	200	2

TABLE 9 Ixodid ticks collected from two white-tailed mongooses in the Kruger National Park

Tick species	Number of ticks collected					No. of mongooses infested
	Larvae	Nymphs	Males	Females	Total	
Amblyomma hebraeum	23	0	0	0	23	1
Amblyomma marmoreum	7	0	0	0	7	2
Haemaphysalis zumpti	0	0	0	1	1	1
Hyalomma truncatum	1	0	0	0	1	1
Rhipicephalus appendiculatus	0	8	0	0	8	2
Rhipicephalus zambeziensis	15	3	0	0	18	2

TABLE 10 Ixodid ticks collected from two banded mongooses in the Kruger National Park

Tick species	Number of ticks collected					No. of mongooses infested
	Larvae	Nymphs	Males	Females	Total	
Amblyomma hebraeum	0	4	0	0	4	2
Amblyomma marmoreum	7	0	0	0	7	1
Haemaphysalis leachi/zumpti	2	0	–	–	2	1
Haemaphysalis zumpti	–	–	1	1	2	1
Rhipicephalus appendiculatus	1	0	0	0	1	1
Rhipicephalus simus	2	0	0	0	2	1
Rhipicephalus zambeziensis	653	99	0	0	752	2

TABLE 11 Ixodid ticks collected from six spotted hyaenas in the Kruger National Park and three on a wildlife farm in north-eastern KwaZulu-Natal

Tick species	Number of ticks collected					No. of hyaenas infested
	Larvae	Nymphs	Males	Females	Total	
Amblyomma hebraeum	792	454	0	0	1 246	7
Amblyomma marmoreum	0	15	0	0	15	2
Haemaphysalis leachi/zumpti	18	2	–	–	20	1
Haemaphysalis leachi	–	–	2	0	2	1
Haemaphysalis zumpti	–	–	6	2	8	3
Ixodes sp.	2	0	0	1	3	2
Rhipicephalus appendiculatus	0	2	2	0	4	2
*Rhipicephalus maculatus**	0	0	1	0	1	1
Rhipicephalus simus	0	0	23	18	41	6
*Rhipicephalus zambeziensis***	4	28	0	0	32	4

* Present only in north-eastern KwaZulu-Natal

** Present only in the Kruger National Park

TABLE 12 Ixodid ticks collected from an old ratel (honey badger) in the Kruger National Park

Tick species	Number of ticks collected				
	Larvae	Nymphs	Males	Females	Total
Amblyomma hebraeum	152	62	34	18	266
Boophilus decoloratus	415	1 454	1 139	605	3 613
Haemaphysalis aciculifer	0	0	13	2	15
Hyalomma truncatum	0	0	4	4	8
Rhipicephalus appendiculatus	61	230	8	4	303
Rhipicephalus evertsi evertsi	24	34	26	10	94
Rhipicephalus simus	0	0	2	0	2

TABLE 13 Ixodid ticks collected from five civet cats in the Kruger National Park and one in a nearby Mpumalanga Parks Board nature reserve

Tick species	Number of ticks collected					No. of civets infested
	Larvae	Nymphs	Males	Females	Total	
Amblyomma hebraeum	1 301	254	12	3	1 570	5
Amblyomma marmoreum	16	20	0	0	36	4
Boophilus decoloratus	58	14	0	0	72	2
Haemaphysalis leachi/zumpti	5	3	–	–	8	4
Haemaphysalis leachi	–	–	85	23	108	4
Haemaphysalis zumpti	–	–	80	12	92	3
Ixodes sp.	268	41	0	2	311	2
Rhipicephalus appendiculatus	19	21	9	2	51	4
*Rhipicephalus kochi**	0	1	0	0	1	1
Rhipicephalus simus	1	0	92	33	126	3
Rhipicephalus zambeziensis	97	13	4	2	116	4
*Rhipicephalus zumpti**	0	0	1	0	1	1

* Present on a single civet cat at Pafuri in the north-east of the Kruger National Park

TABLE 14 Ixodid ticks collected from four large spotted genets in the Kruger National Park and from four in the Mthethomusha Nature Reserve, Mpumalanga Province

Tick species	Number of ticks collected					No. of genets infested
	Larvae	Nymphs	Males	Females	Total	
Amblyomma hebraeum	22	9	1	1	33	5
Amblyomma marmoreum	13	3	0	0	16	6
Boophilus decoloratus	2	0	0	0	2	1
Haemaphysalis leachi/zumpti	11	12	–	–	23	5
Haemaphysalis zumpti	–	–	98	20	118	8
Ixodes sp.	0	1	0	0	1	1
Rhipicephalus appendiculatus	26	1	0	0	27	4
Rhipicephalus simus	1	0	0	0	1	1
Rhipicephalus zambeziensis	1	0	0	0	1	1

TABLE 15 Ticks collected from a black-backed jackal, a leopard and a brown hyaena

Carnivore species	Locality	Number of ticks collected					
		H. leachi		*R. nuttalli*		*R. simus*	
		Males	Females	Males	Females	Males	Females
Black-backed jackal	Verkeerdevlei, Free State	4	5	1	0	0	0
Leopard	Roodeplaat Dam, Gauteng	1	6	9	10	0	0
Brown hyaena	Bon Accord, Gauteng	8	7	1	0	5	0

R. nuttalli = *Rhipicentor nuttalli*

TABLE 16 Ixodid ticks collected from wild carnivores in the Kammieskroon district, north-western Northern Cape Province

Carnivore species	No. examined	No. of ticks collected			
		H. zumpti		*I. rubicundus*	
		Males	Females	Males	Females
Black-backed jackal	1	0	1	19	26
Caracal	1	3	0	0	1
African wild cat*	1	1	3	5	3
Small grey mongoose	1	28	15	0	0
Meercat	1	1	0	0	0

* *Ixodes pilosus* group 2 females

TABLE 17 Ixodid ticks collected from seven ratels (honey badgers) in the south-west of the Kgalagadi Transfrontier Park, northern Northern Cape Province and one near Bredasdorp in the Western Cape Province

Tick species	Number of ticks collected			No. of ratels infested
	Males	Females	Total	
Haemaphysalis zumpti	6	13	19	7
Rhipicephalus theileri	0	1	1	1

TABLE 18 Ixodid ticks collected from wild carnivores in the south-western Free State

Carnivore species	Number of ticks collected							
	A. marmoreum		*H. lea/zumpt*		*H. zumpti*		*R. warburtoni*	
	LL	NN	LL	NN	Males	Females	LL	Males
Black-backed jackal	48	1	0	0	4	1	0	0
Bat-eared fox	1	0	1	1	0	0	0	0
Bat-eared fox	0	0	3	5	0	0	0	0
Cape fox	0	0	1	8	1	0	0	0
Cape fox	0	0	0	2	0	0	0	0
Caracal*	8	0	0	0	6	3	1	0
African wild cat**	0	0	0	0	0	0	0	1
Aardwolf	0	0	0	2	1	0	0	0
Zorilla	0	0	0	5	6	0	0	0

* *Ixodes rubicundus* 1 larva, 3 females
** *Haemaphysalis leachi* 4 males, 21 females

Fourteen species of wild carnivores were examined in the five provinces. Four genets, of undetermined species were also examined. Fourteen ticks were identified to species level on these animals.

Twenty-four ixodid tick species belonging to seven genera were collected from the 111 carnivores examined. Five of these species belonged to the genus *Haemaphysalis* and 12 to the genus *Rhipicephalus*. The presence of a species on a particular animal depended upon host preference, host size and geographic distribution. Thus adult *H. leachi*, *H. zumpti*, and *R. simus*, all species that prefer carnivores as hosts, were collected from nine, 19 and 10 carnivore species respectively. Both *Amblyomma hebraeum* and *Amblyomma marmoreum* have widespread distributions (Theiler 1962; Howell, Walker & Nevill 1978; Walker & Olwage 1987), and their immature stages infest a large variety of hosts (Theiler 1962; Norval 1975; 1983; Horak, MacIvor, Petney & De Vos 1987a). The latter were collected from 14 and 13 host species respectively. In contrast *Rhipicephalus kochi*, that has a very restricted distribution range in the far north-east of South Africa (Walker *et al.* 2000), was collected from a single civet cat examined near Pafuri in the Northern Province.

Some of the animals examined in the Kruger National Park, notably three of the lions, the ratel and a civet cat, were injured, emaciated or old. These animals were generally heavily infested, sometimes with ticks that do not normally favour carnivores as hosts. However, we feel their inclusion in this communication is warranted for the benefit of other acarologists or for zoologists and other scientists studying carnivores.

Amblyomma spp.

The adults of the three species collected in this genus, namely *A. hebraeum*, *A. marmoreum* and *A. tholloni*, prefer large herbivores, tortoises and African elephants (*Loxodonta africana*) respectively as hosts (Norval 1983; Horak *et al.* 1987a; Petney, Horak & Rechav 1987; Walker & Olwage 1987). The immature stages of the former two may be found on the same hosts as the adults as well as on a large variety of smaller mammals, excluding rodents, and also on birds (Theiler 1962; Norval 1975; 1983; Horak *et al.* 1987a).

The presence of more than one or two adult *A. hebraeum* on a wild carnivore smaller than a lion must be viewed as unusual and evidence of stress in the host animal. Even healthy lions should not harbour more than a few adults in an environment that is otherwise heavily infested. The hosts of the immature stages of *A. tholloni* are elephants, but birds, reptiles and other wild mammals can also be infested (Hoogstraal 1956; Theiler 1962; Petney *et al.* 1987; Walker 1991). Larvae and nymphs have also been collected from domestic cattle, sheep and goats (MacKenzie & Norval 1980; Norval 1983). The recovery of two nymphs from one of the lions must be viewed as an accidental infestation in a habitat in which there are many elephants.

Boophilus decoloratus

The preferred hosts of this one-host tick are domestic and wild ruminants and equids, with cattle, tragelaphine antelopes and impalas (*Aepyceros melampus*) being particularly favoured (Mason & Norval 1980; Horak *et al.* 1992). Infestation of carnivores, suids, rodents and other groups of mammals must be regarded as accidental and usually occurs in habitats in which the preferred hosts of this tick abound. Large infestations on the former animals, such as that on the ratel in the Kruger National Park, are probably due to an immune-compromised system coupled with ineffective grooming.

TABLE 19 Ixodid ticks collected from wild carnivores in the Eastern Cape Province

Carnivore species	Number of ticks collected													
	A. hebraeum	*A. marmoreum*		*H. silacea*		*H. zumpti*				*Ixodes* sp.		*R. evertsi*		*R. simus*
	Larvae	LL	NN	LL	NN	LL	NN	MM	FF	LL	NN	LL	NN	Males
Black-backed jackal	4	0	22	113	0	0	0	0	0	0	0	12	0	1
Cape fox	0	0	0	1	0	0	0	0	0	0	0	0	2	0
Yellow mongoose	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Small grey mongoose	0	1	0	0	0	0	0	1	0	0	1	0	0	0
Small grey mongoose*	0	64	0	0	0	0	0	6	0	2	0	0	0	0
Aardwolf**	0	0	0	0	2	55	177	3	3	0	0	0	3	1
Zorilla	0	0	0	0	0	0	0	3	0	0	0	0	0	0
Small-spotted genet	1	0	0	1	0	1	2	53	15	0	0	0	0	0
"Genet"	0	0	0	0	0	0	0	0	1	0	0	0	0	0
"Genet"	0	0	0	0	0	0	0	3	1	0	1	0	0	0
"Genet"	0	0	0	0	0	0	0	3	0	21	15	0	0	0

* *Rhipicephalus arnoldi* 1 larva; *Rhipicephalus follis* 16 larvae, 1 nymph
** *Boophilus decoloratus* 8 larvae

Haemaphysalis spp.

The adults of *H. leachi* and *H. spinulosa* are parasites of domestic and wild carnivores, with the former tick preferring the larger species and the latter smaller animals (Walker 1991). Although some of their immature stages can be present on the same animals as the adults, rodents are their preferred hosts (Hoogstraal 1956; Norval 1984). *Haemaphysalis zumpti* is a parasite of small carnivores, particularly yellow mongooses and meercats (Hoogstraal & El Kammah 1974; Walker 1991; Horak *et al.* 1999). Yellow mongooses and Cape ground squirrels (*Xerus inauris*), which often share burrows with the mongooses, are hosts of the immature stages (Walker 1991; Horak *et al.* 1999). The presence of these *Haemaphysalis* species on the animals from which they were collected thus confirms earlier observations on their host preferences. However, *H. zumpti* is far more prevalent and widespread than previously suspected. The numerous immature *Haemaphysalis* spp. collected from the carnivores could well be *H. zumpti*, of which the pre-imaginal stages prefer these animals as hosts.

Haemaphysalis leachi is widespread in the warm, moist eastern regions of South Africa (Howell *et al.* 1978), but will probably occur wherever sufficient, suitable rodent and carnivore hosts are present (Norval 1984). *Haemaphysalis zumpti* appears to be present wherever the hosts of its adults occur (Walker 1991; Horak *et al.* 1999).

Adult *H. aciculifer* has been recorded on carnivores (Norval 1985), but its preferred hosts are wild bovids, both large and small, on which, however, it seldom occurs in large numbers (Walker 1991; Horak, Keep, Spickett & Boomker 1989). Since 1977 one of us (I.G.H.) has examined well over 1 200 animals belonging to many species in the Kruger National Park and has collected a total of only two male *H. aciculifer* from a single eland (*Taurotragus oryx*) (Horak, Potgieter, Walker, De Vos & Boomker 1983). The collection of 15 adults from the ratel examined in the Park is thus remarkable and probably reflects unique conditions within its immediate surroundings. *Haemaphysalis silacea* is a parasite of domestic and wild ruminants and occurs only in South Africa, where it is found in Valley Bushveld in the Eastern Cape Province and in north-eastern KwaZulu-Natal (Baker & Keep 1970; Walker 1991; Horak *et al.* 1992). Its recovery from some of the animals examined in the present survey is more a reflection of its superabundance at a particular locality than of host preference.

Hyalomma truncatum

The small numbers of adult ticks collected confirm that carnivores are not good hosts of this tick. It prefers large ungulates, usually with thick skins (Walker 1991). The recovery of immature ticks from some of the carnivores is unusual and must be considered accidental because their preferred hosts are hares and rodents (Horak & Fourie 1991; Walker 1991).

Ixodes spp.

Considerable doubt as to the identity of some of the *Ixodes* spp. in the *I. pilosus* group exists (Walker 1991), hence our failure to identify them specifically. Both the immature and adult stages of *I. rubicundus* have previously been collected from medium-sized wild carnivores in the Karoo, South Africa (Stampa 1959), and caracals have been identified as preferred hosts of this tick (Horak *et al.* 1987b). The present collection of adults from two caracals, an African wild cat and a black-backed jackal, indicates that medium-sized carnivores should be considered amongst its preferred hosts.

Rhipicentor nuttalli

Adults of this tick have been collected from a number of wild carnivores and Norval & Colborne (1985) consider the leopard to be the host of choice in Zimbabwe. Other common hosts are the South African hedgehog (*Atelerix frontalis*) and porcupine (*Hystrix africaeaustralis*) (Norval & Colborne 1985; Walker 1991). The preferred hosts of the immature stages are rock elephant shrews (*Elephantulus myurus*) (Du Toit 1993). No adult *R. nuttalli* were found on any of the carnivores in the Kruger National Park, but the immature stages have been collected from rock elephant shrews in the north of the Park (Horak & Braack, unpublished data 1999). In the present survey adults were collected from a leopard and a brown hyaena near Pretoria, Gauteng Province, and from a black-backed jackal in the central Free State.

Rhipicephalus spp.

Although 12 species of *Rhipicephalus* were collected from the wild carnivores, we consider only two, namely *R. simus* and *R. turanicus*, to be true parasites of these animals. However, the adults of both these ticks also parasitize a variety of other hosts. *Rhipicephalus simus* is found on equids, suids and large ruminants and *R. turanicus* on ruminants, hares and large birds (Walker *et al.* 2000). The immature stages of *R. simus* prefer murid rodents as hosts, while those of *R. turanicus* are found on rodents and other small mammals (Norval & Mason 1981; Walker *et al.* 2000). *Rhipicephalus simus* is widespread in South Africa, particularly in the moister northern, eastern and southern regions of the country. *Rhipicephalus turanicus* is present in the northern provinces, north-eastern KwaZulu-Natal and in the arid southern regions around Oudtshoorn, Western Cape Province (Walker *et al.* 2000). The abundance of the adults of both ticks is closely related to the availability of rodent hosts for the immature stages. Peak

numbers of adults have been collected from the vegetation in the south east of the Kruger National Park 8 months after a rodent population explosion (Horak, Spickett & Braack 2000). *Rhipicephalus sanguineus*, which is closely related to *R. turanicus* (Pegram *et al.* 1987; Walker *et al.* 2000), is commonly encountered on domestic dogs in South Africa (Horak 1995; Bryson, Höhn, Horak & Kirkpatrick 1998), but was not collected from any of the wild carnivores examined.

The preferred hosts of all stages of development of *R. appendiculatus*, *R. zambeziensis* and *R. evertsi evertsi* are domestic and wild ruminants, and of the latter tick also equids (Norval 1981; Norval, Walker & Colborne 1982; Walker *et al.* 2000).

Numerous adults of the former two species have also been collected from a lion and a leopard (Horak *et al.* 1987b). However, we do not believe that this and the present findings on lions make them preferred hosts. *Rhipicephalus evertsi evertsi* is particularly widespread in South Africa (Theiler 1950), and its immature stages have been collected from a large variety of hosts (Theiler 1962; Walker *et al.* 2000). The small numbers collected from the carnivores are hence not unexpected. The many adults collected from the ratel in the Kruger National Park can probably be ascribed to its debilitated state.

Immature and adult *Rhipicephalus theileri* prefer yellow mongooses and meercats as hosts, and are also found on Cape ground squirrels (Horak *et al.* 1999; Walker *et al.* 2000). This tick occurs mainly in the dryer western regions of South Africa and Namibia (Walker *et al.* 2000), and its presence on one of the ratels examined in the south-western Kgalagadi Transfrontier Park within the Northern Cape Province is thus not surprising.

One of the Cape grey mongooses examined in the Eastern Cape Province was collected in the Mountain Zebra National Park and in addition to other ticks harboured a single *Rhipicephalus arnoldi* larva and several larvae and a nymph of *Rhipicephalus follis*. Both these ticks are common in this park, the first on Smith's red rock rabbits (*Pronolagus rupestris*) and the latter on eland, while their immature stages infest a variety of small mammals (Horak, Fourie, Novellie & Williams 1991).

The adults of *R. kochi* and *R. zumpti* may occur on carnivores but have restricted distributions in South Africa. Both are present in the far north-eastern regions of the country and the latter tick also in the south (Walker *et al.* 2000). The adults of *R. maculatus* are parasites of thick-skinned mammals such as white and black rhinoceroses (*Ceratotherium simum* and *Diceros bicornis*), warthogs (*Phacochoerus africanus*) and African buffaloes (*Syncerus caffer*) in the north-eastern coastal regions of South Africa (Baker & Keep 1970; Walker *et al.* 2000). The presence of a single male on one of the spotted hyaenas in KwaZulu-Natal must be considered an accidental infestation.

Rhipicephalus warburtoni is virtually confined to the central, western and south-western Free State where its adults parasitize domestic and wild ruminants and scrub hares and its immature stages scrub hares and rock elephant shrews (Walker *et al.* 2000). Infestation of wild carnivores would seem to be accidental.

General

Of all the tick species collected in this survey we consider the adults of *H. leachi*, *H. spinulosa*, *H. zumpti*, *I. rubicundus*, *R. nuttalli*, *R. simus* and *R. turanicus* to be true parasites of wild carnivores. All these species may parasitize various wild carnivores, and some are also true parasites of animals belonging to completely different classes. Adult *H. leachi*, *H. spinulosa*, *R. simus* and *R. turanicus* are also frequently collected from domestic dogs (Horak *et al.* 1987b; Horak 1995; Walker *et al.* 2000). Excluding *H. zumpti*, the immature stages of the other six ticks prefer hosts other than wild carnivores, and more especially murid rodents or elephant shrews (Norval & Mason 1981; Norval 1984; Walker 1991; Fourie, Horak & Van Heerden 1992; Du Toit 1993; Walker *et al.* 2000). This is in sharp contrast to the kennel tick, *R. sanguineus*, which in all its developmental stages virtually parasitizes only domestic dogs (Walker *et al.* 2000).

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