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HELMINTHS AND ARTHROPODS OF BLACK AND WHITE RHINOCEROSES IN SOUTHERN AFRICA

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ABSTRACT: Helminths and arthropods were collected and quantified from two black rhinoceroses (*Diceros bicornis bicornis*) and one white rhinoceros (*Ceratotherium simum*), and ticks from an additional four black and two white rhinoceroses in southern Africa. The helminths of a black rhinoceros from the Republic of South Africa and one from Namibia were quantitatively measured and recorded for each compartment of the alimentary tract. *Probstmayria vivipara* was the most abundant parasite in each animal. A recently described nematode, *Diceronema versterae*, was found in the stomach of one animal. *Draschia megastoma* was present in the descending colon of the same animal, but it was twice the size of similar specimens reported from equids and the typical granulomatous lesions caused by this nematode in horses were not observed. New records of other helminths from rhinoceroses include *Parabronema roundi*, *Kiluluma* sp., *Kiluluma goodeyi*, *Kiluluma magna*, *Khalilia rhinocerotis*, *Oxyuris karamoja* and *Anoplocephala gigantea*. The stomach bot, *Gyrostigma pavesii*, was collected from one black and one white rhinoceros. Ticks collected from the black rhinoceroses were *Amblyomma hebraeum*, *Dermacentor rhinocerinus*, *Rhipicephalus maculatus*, *Rhipicephalus muehlensi* and *Haemaphysalis silacea*. The two white rhinoceroses were infected with *A. hebraeum*, *D. rhinocerinus*, *Hyalomma truncatum*, *Rhipicephalus simus*, *Rhipicephalus appendiculatus* and *Rhipicephalus zambeziensis*.

Key words: Black rhinoceros, *Diceros bicornis bicornis*, white rhinoceros, *Ceratotherium simum*, nematodes, cestodes, acari, bots.

INTRODUCTION

The rhinoceroses, both black (*Diceros bicornis bicornis*) and white (*Ceratotherium simum*) are endangered species. In southern Africa there is great interest in the management and protection of these animals (Walker, 1994) with particular concern for their diseases (Meltzer, 1994) and parasites (Penzhorn et al., 1994). Von Linstow (1907) published the first description of a helminth from a rhinoceros. Since then, there have been numerous reports of arthropods and helminths from these animals (Zumpt, 1964). Most of the parasite studies have been taxonomic, although there have been a few reports describing nematode-induced skin lesions (Round, 1964; Young, 1966; Hitchins and Keep, 1970; Kock and Kock, 1990). Checklists of the helminths of rhinoceroses compiled by Round (1968) and Penzhorn et al. (1994) provided a comprehensive documentation of all the parasites that have been recorded from both black and white rhinoceroses.

Zumpt (1965) reported larvae of the gasterophilid fly *Gyrostigma pavesii* from both black and white rhinoceroses, and indicated that this fly may be expected wherever its hosts still occur in Africa. Checklists of the ixodid ticks collected from black and white rhinoceroses south of the Sahara Desert have been prepared by Theiler (1962), while Baker and Keep (1970) have compiled such lists for black and white rhinoceroses in KwaZulu-Natal (Republic of South Africa). Walker (1991), in a review of ixodid ticks occurring in southern Africa, mentioned that adults of two ticks, *Amblyomma rhinocerotis* and *Dermacentor rhinocerinus*, feed primarily on black and white rhinoceros. While the immature stages of *A. rhinocerotis* are unknown (Walker, 1991), the larva of *D. rhinocerinus* recently has been described for the first time and the nymph and adults were redescribed (Keirans, 1993).

In this study, we present quantitative data on the helminths and arthropods collected from a black rhinoceros in the Re-

public of South Africa and another in Namibia. Also included are the identifications of some parasites collected from a white rhinoceros in the Republic of South Africa. In addition, quantitative data are presented for ticks collected on another four black and two white rhinoceroses in the Republic of South Africa.

MATERIALS AND METHODS

A female black rhinoceros with calf died during June 1993 in the Umfolozi section of the Hluhluwe-Umfolozi Park (KwaZulu-Natal, Republic of South Africa; 28°12' to 28°21'S, 31°42' to 31°59'E). The two vegetation types recognized in this reserve are Zululand Thornveld along the slopes and crests of the hills and Lowveld in the valleys (Acocks, 1988).

In Namibia, a 30-yr-old male black rhinoceros was killed in July 1989 because its lip and lower mandible were injured, resulting in deterioration of its condition. This rhinoceros ranged in the western part of the Etosha National Park (Namibia; 18°55'S, 15°31'E). The dominant vegetation type is saline desert with dwarf shrub savanna fringe and mopane savanna (Giess, 1971).

The death of a white rhinoceros, in June 1991 in the Hluhluwe-Umfolozi Park provided the opportunity to collect internal parasites. Unfortunately, the animal had been dead for 1 day before ingesta samples were collected so quantitative estimates of parasite species were not performed. A few helminths could be identified and these are reported herein.

The culling of a problem black rhinoceros in the Addo Elephant National Park (Eastern Cape Province, Republic of South Africa; 33°27'S, 25°44'E) in a vegetation zone classified as Valley Bushveld (Acocks, 1988); the immobilization of three black rhinoceroses in the Ndumu Game Reserve northern KwaZulu-Natal, Republic of South Africa; 26°53'S, 32°15'E) in a vegetation zone classified as a Lowveld subtype of Tropical Bush and Savannah (Acocks, 1988); and the death, due to injuries, of two white rhinoceroses in the southern region of Kruger National Park (northeastern Mpumalanga, Republic of South Africa; south of 24°24'S, 31°15' to 31°55'E) in a vegetation zone classified as Arid Lowveld and Lowveld (Acocks, 1988), presented the opportunity for collecting additional ticks.

Each rhinoceros, excluding the six involved in the tick study, was processed for the collection of internal parasites following procedures used in equids (Malan et al., 1981a, 1981b). All organs were examined and samples from the

gastrointestinal tracts collected. Quantitative samples were collected from the ingesta in the stomach, small intestine and the four sections of the large intestine. Aliquot sizes of the ingesta from rhinoceroses in Namibia were limited because of the high financial costs of carrying these samples as accompanying baggage on an airline flight. Samples (5% of the mass) were collected for transport back to the laboratory and the remainder examined macroscopically at post-mortem examination. The ingesta from the black rhinoceros from KwaZulu-Natal was collected totally. A 1% sample of the total was examined microscopically, if counts were <100 helminths, a second 1% sample was examined. For the white rhinoceros, 20% of stomach and small intestine ingesta were collected and 10% of the remaining material came from compartments of the alimentary tract. Up to 10% of the remaining ingesta was examined macroscopically. Usually 10% of the intestinal serosa was frozen and then examined with an illuminated diamond sorting lamp for fourth stage larvae of cyathostome nematodes. Many of these parasites were in such poor condition that specific identifications could not be determined and quantitative counts were not completed. Samples of all organs were placed in 10% formalin for histopathological examination, but pathological lesions were not noted. Thin blood smears were made from the Namibian black rhinoceros and stained with Giemsa's stain, according to standard procedures, for the presence of protozoan parasites. Larvae of the gasterophilid fly *G. pavesii* were collected from the mucosal wall and contents of the stomach. Ixodid ticks were collected from the skins of the dead black rhinoceros and the two dead white rhinoceroses as described by Horak et al. (1992b). Ticks were collected by hand from three black rhinoceroses after the animals had been immobilized. All the ticks were identified and counted using a stereoscopic microscope.

Nematodes were identified to genus using the descriptive data and keys in Anderson et al. (1974) and Lichtenfels (1975), as well as various checklists (Round, 1968; Penzhorn et al., 1994) or descriptive reports (Thapar, 1924; 1925; Fitzsimmons, 1962; Neveu-Lemaire, 1924; Baylis, 1939; Usui and Horii, 1985; Ezzat, 1945). Stunkard (1926) was used as the authority for identification of cestodes. Stomach bots were identified from descriptions given by Zumpt (1964). Representative specimens of helminths and arthropods collected in this study are deposited in the United States National Parasite Collection (Biosystematics and National Parasite Collection Unit, United States Department of Agriculture, Beltsville,

TABLE 1. Helminth and gasterophilid parasites from black rhinoceros in the Republic of South Africa and Namibia.

Species of parasites	South Africa (n=2) ^b		Namibia (n=2) ^b	
	Preferred sites in host ^a	Total numbers	Preferred sites in host ^a	Total numbers
Nematoda				
<i>Kiluluma goodeyi</i>	C	1,310		
<i>Kiluluma magna</i>	A	5,420		
<i>Kiluluma rhinocerotis</i>	C	18,490	C, A	2,720
<i>Diceronema versterae</i>	S	2,100		
<i>Probstmayria vivipara</i>	C	17,858,200	C, A, D	385,360,000
<i>Draschia megastoma</i>	D	100		
<i>Parabronema roundi</i>	S	4,200		
<i>Oxyuris karamoja</i>	A	250	C, A	80
Cestoda				
<i>Anoplocephala gigantea</i>	I	1,698	I	1,400
Diptera				
<i>Gyrostigma pavesii</i>	S	168		

^a S, stomach; I, small intestine; C, cecum; A, ascending colon; D, descending colon.

^b n = number of hosts examined.

Maryland, U.S.A.; Accession numbers 84763-84784).

RESULTS AND DISCUSSION

Three nematode and one cestode species were collected from the black rhinoceros in Namibia (Table 1). Protozoa were not found in the blood smears. *Probstmayria vivipara* was the most numerous of the helminths collected and was present in the cecum, descending colon and ascending colon. *Kiluluma rhinocerotis* was present in substantial numbers in the cecum and the ascending colon. A large number of scoleces of the cestode *Anoplocephala gigantea* were present in the small intestine.

A greater variety of helminths, gasterophilid and arthropods were found in the black rhinoceros from the Hluhluwe-Umfolozi Park (Tables 1 to 3). A recently described genus and species of nematode, *Diceronema versterae* (Atractidae), was found in the stomach (Gibbons et al., 1996). *Parabronema roundi* also occurred in substantial numbers in the stomach as well as *Gyrostigma pavesii*, the stomach bot. The small intestine contained a few *Kiluluma* sp., *K. goodeyi* and *K. magna*. *Parahronema vivipara* were abundant and

many scoleces of *A. gigantea* were present. The cecum contained the greatest numbers of the three *Kiluluma* spp. *Parahronema vivipara* were present in enormous numbers. A few specimens of *Kiluluma* spp. were found in the descending colon along with a substantial number of *P. vivipara* and small numbers of *Oxyuris karamoja* and *Draschia megastoma*. The three *Kiluluma* spp. were present in the colon, with *K. magna* being the most abundant followed by *Kiluluma* sp. and *K. goodeyi*. *Oxyuris karamoja* was abundant in the ascending colon as was *P. vivipara*. Immature nematodes were not identified.

In the white rhinoceros from KwaZulu-Natal, we identified only a few specimens of internal parasites since most of the helminths in the ingesta had deteriorated and could not be identified. These included four second instar and two third instar larvae of *G. pavesii* from the stomach; *K. rhinocerotis* from the cecum; *K. rhinocerotis* and *O. karamoja* from the descending colon and *P. vivipara* from the ventral colon (Table 1).

The numbers of ticks collected from the black and white rhinoceroses are summa-

rized in Tables 2 and 3. The black rhinoceros from the Addo Elephant National Park had two species of ticks while the three from the Ndumu Game Reserve were infected with four species of ticks. The two white rhinoceroses from the Kruger National Park had six species of ixodid ticks.

Scanning electron micrographs of six *Kiluluma* spp., *Khalilia rhinocerotis* and *Draschia megastoma* are presented in Figures 1–8. These were used in the identification and differentiation of these species (see below).

Anoplocephala gigantea (Cestoda, Anoplocephalidae) was originally described from a black rhinoceros from Mozambique (Peters, 1856) and subsequently reported from a white rhinoceros from Zaire (Stunkard, 1926) and the Republic of South Africa (Mönnig, 1928) and from both black and white rhinoceroses (Zumpt, 1964) in the Republic of South Africa. It was present in the small intestines of both black rhinoceroses we examined and this is the first report for this parasite from Namibia.

Kiluluma rhinocerotis (Nematoda, Cyathostominae) was first described by Neveu-Lemaire (1924) from a black rhinoceros in Ethiopia. We found this species in both the black rhinoceros from Namibia and the white rhinoceros from the Republic of South Africa. Body measurements for nematodes from both hosts were similar to those of the original description. This is the first report of this parasite subsequent to its original description and our findings represent a new host record for the white rhinoceros and new geographic records for southern Africa.

The genus *Kiluluma* was created by Skrjabin (1916) in response to a need for a more appropriate generic name for a rhinoceros nematode that had been described earlier by von Linstow (1907); *Deletocephalus stylosus* of von Linstow (1907) did not exhibit generic characteristics in common with the type species *D. dimidiatus* and the first recorded strongylid nematode of the rhinoceros was re-

TABLE 2. Ixodid ticks on four black and two white rhinoceroses in the Republic of South Africa.

Rhinoceros		Total numbers of ticks collected										Other ticks
		<i>Amblyomma hebraeum</i>			<i>Dermacentor rhinocerotus</i>		<i>Hyalomma truncatum</i>		<i>Rhipicephalus maculatus</i>		<i>Rhipicephalus simus</i>	
Age	Sex	Larvae	Nymphs	Adults	Adults	Adults	Adults	Nymphs	Adults	Adults		
Addo Elephant National Park (Black rhinoceros)												
Adult	M	293	394	1,211	0	0	0	0	0	0	<i>Haemaphysalis silacea</i>	
Ndumu Game Reserve (Black rhinoceroses)												
Calf	F	0	8	48	8	0	0	40	352	0	<i>Rhipicephalus muchlensi</i>	
Adult	F	0	0	62	2	0	0	28	266	0		
Adult	M	0	6	66	8	0	0	114	504	0	<i>Rhipicephalus muchlensi</i>	
Kruger National Park (White rhinoceroses)												
Adult	F	122	222	686	116	4	0	0	0	66	<i>Rhipicephalus appendiculatus</i>	
Adult	M	22	220	987	72	2	0	0	0	7	<i>Rhipicephalus zambesiensis</i>	

TABLE 3. Ixodid tick species reported on white and black rhinoceroses in the Republic of South Africa and Zimbabwe.

Tick species	Republic of South Africa		Zimbabwe	
	Theiler (1962), Baker and Keep (1970), present study		Norval (1985)	
	White	Black	White	Black
<i>Amblyomma hebraeum</i>	+	+	+	—
<i>Amblyomma rhinocerotis</i>	+	+	—	+
<i>Amblyomma sparsum</i>	—	—	—	+
<i>Amblyomma tholloni</i>	—	+	—	—
<i>Dermacentor rhinocerosus</i>	+	+	+	+
<i>Haemaphysalis silacea</i> ^a	—	+ ^b	—	—
<i>Hyalomma marginatum rufipes</i>	—	+	+	—
<i>Hyalomma truncatum</i>	+	+	+	—
<i>Rhipicephalus appendiculatus</i>	+	+	+	—
<i>Rhipicephalus capensis</i>	—	+	—	—
<i>Rhipicephalus compositus</i>	—	—	—	+
<i>Rhipicephalus evertsi evertsi</i>	—	—	+	—
<i>Rhipicephalus lunulatus</i>	—	—	—	+
<i>Rhipicephalus maculatus</i>	+	+	—	—
<i>Rhipicephalus muelhensi</i>	—	+	—	—
<i>Rhipicephalus simus</i>	+	+	+	—
<i>Rhipicephalus zambeziensis</i> ^a	+ ^c	—	—	—
<i>Rhipicephalus zumpti</i>	—	+	—	—

^a New record.^b Only larvae.^c Single nymph only.

named *Kiluluma stylosa* by Skrjabin (1916). Thapar (1924) rejected the species description on the basis that the measurements cited by Skrjabin (1916) were different from those given by von Linstow (1907). He subsequently described six new species of this genus *Kiluluma* from a collection of strongylid nematodes collected by R. T. Leiper from the large intestine of a black rhinoceros in Uganda and named them *K. rhinocerotis*, *K. africana*, *K. pachyderma*, *K. macdonaldi*, *K. solitaria* and *K. magna*. Later, Thapar (1925), studying the same collection, described four additional species as *K. goodeyi*, *K. brevicauda*, *K. brevivaginata* and *K. cylindrica*. Taylor (1925) concluded that all of the species described above except *K. magna* were probably the same species; *K. rhinocerotis*, *K. africana*, *K. pachyderma* and *K. solitaria* were considered as synonyms and it was suggested that *K. macdonaldi* also might belong with this group. However, Taylor

(1925) did not suggest which species names should be used. A nearly similar conclusion was recorded by Yorke and Maplestone (1926) after examining the same collection of parasites as Taylor (1925); they observed that only one species of the genus was present.

An eleventh species of the genus was described by Mönnig (1926) from a collection of parasites from rhinoceroses from the Republic of South Africa. One of these had been labeled as *K. stylosa*. Mönnig (1926) accepted that Thapar (1924) was correct in assuming that *K. stylosa* consisted of several specifically different species, accepted the six new species as valid, reported *K. rhinocerotis*, *K. africana*, *K. pachyderma* and *K. solitaria* in his collection, and described a new species, *Kiluluma longispiculata*, which was later synonymized with *K. goodeyi* in an addendum to his paper (Round, 1968). In a parasite-host checklist for the rhinoceros, Round

(1968) lists all of the above species for the genus *Kiluluma* but acknowledges that Sandground (1933) admonishes “With the possible exception of *K. magna*, which is slightly larger and *K. goodeyi*, *K. brevicaudata* and perhaps *K. brevicauda* in which the male can be distinguished by its longer spicules, the remaining species do not possess clear differential characters.” Round (1968) concludes that “. . . a reexamination of this genus is obviously necessary.”

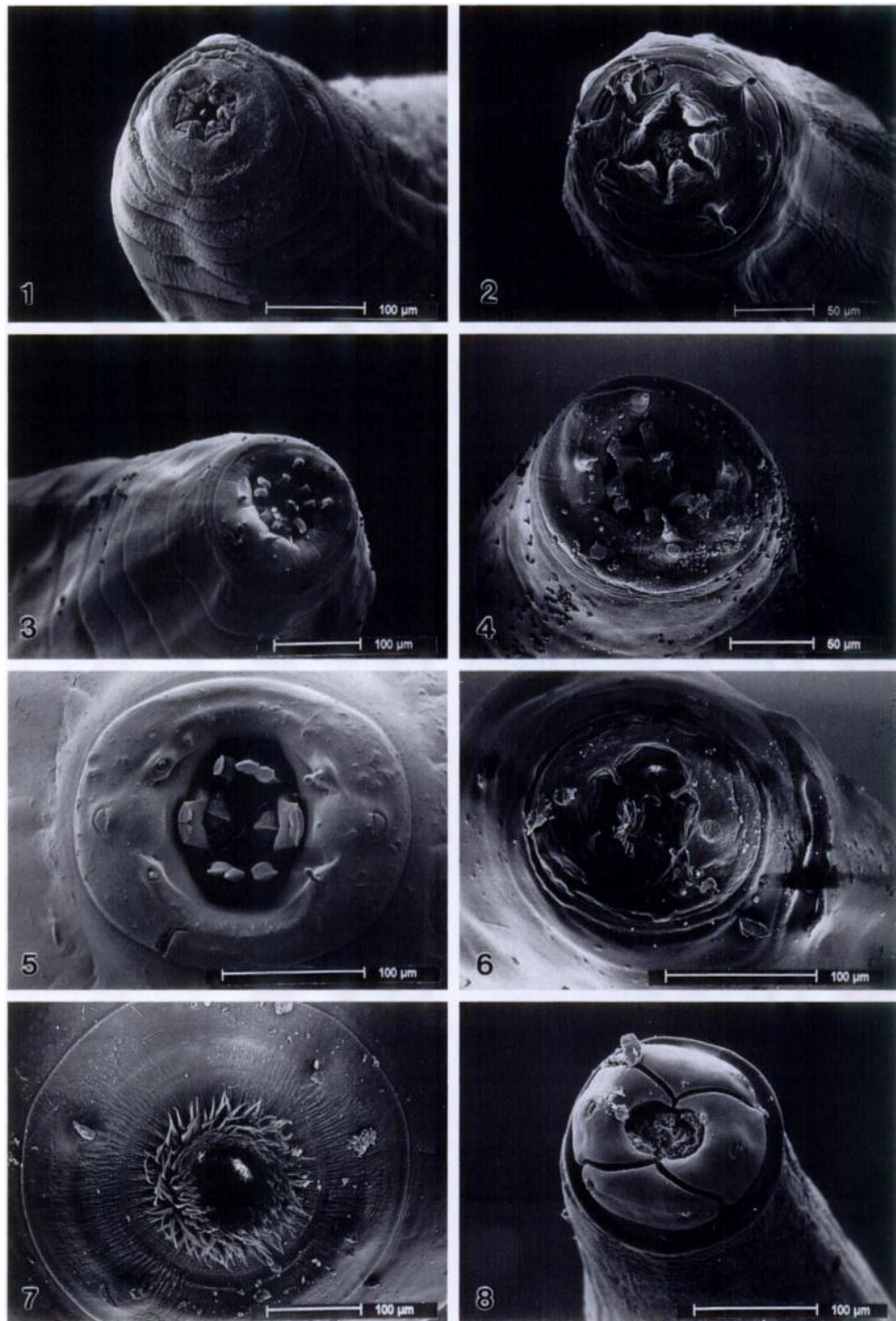
The larger specimens of *Kiluluma* spp. we collected from the black rhinoceros in the Hluhluwe-Umfolozi Park resemble specimens described by Thapar (1924) and Mönnig (1926) as *K. magna* and *K. goodeyi*. We have identified specimens as belonging to these two species based on body size, spicule length and morphology, bursal ray architecture and mouthpart arrangement. Scanning electron microscope photos were made of Mönnig’s (1926) specimens and those from our study; these helped to confirm that the species present in both collections were similar (Figs. 1 to 6). In the case of the remaining specimens of the genus *Kiluluma*, we believe these should be referred to as *Kiluluma* spp. until their taxonomic status can be determined. We propose applying molecular biological techniques which have been used to separate eggs of *Strongylus* spp. (Campbell et al., 1995) to differentiate the *Kiluluma* spp. There were 217 specimens examined in this group. All came from the black rhinoceros from the Hluhluwe-Umfolozi Park. Most of the specimens came from the cecum although some were in the small intestine, ascending colon and descending colon. Excluding *K. magna*, these nematodes ranged in body length from 11 to 23 mm and resembled those described by Thapar (1924). Except for differences in body length, they appeared to be a single species.

Dicronema versterae, recently described by Gibbons et al. (1996), was found in the stomach of the black rhinoceros from the Hluhluwe-Umfolozi Park (Table 1). A few specimens of *D. megas-*

toma also were found in the descending colon of this animal (Fig. 8). This is the first report for this parasite from the rhinoceros in a location other than the stomach where it usually produces tumor-like lesions. There were no intestinal lesions in the rhinoceros. In southern Africa, this parasite has been reported from Burchell’s (*Equus burchelli antiquorum*) and Hartmann’s (*Equus zebra hartmannae*) zebras (Scialdo-Krecek, 1984), and it is frequently found in horses (Lichtenfels, 1975). The specimens from the rhinoceros were twice the length of those from equids, ranging from 19–21 mm and 15–16 mm for females and males, respectively. Other than size, the nematodes from rhinoceros were morphologically similar to those from the zebra and horse. The nematode *Oesophagostomum columbianum*, which infects both sheep and certain antelopes, produces a visible tissue reaction only in sheep (Horak, 1981), another nematode *Impatiaria nudicollis*, which infects various antelopes, is considerably smaller than normal when collected from warthogs (*Phacochoerus aethiopicus*) (Horak et al., 1983a). It was suggested that this could indicate that antelopes are the normal definitive hosts for these parasites and not sheep or warthogs. This also may be the case for *D. megastoma* in the rhinoceros in which there appears to be no tissue damage, but considerably larger specimens of the parasite are found in a different region of the alimentary tract than was reported previously.

Parabronema roundi was found in the stomach of the black rhinoceros in the Hluhluwe-Umfolozi Park. This parasite was first recorded from the intestine of a black rhinoceros in Kenya by Fitzsimmons (1962). This is the first report for this parasite in southern Africa. Another species, *P. rhinocerotis*, has been recorded in the black rhinoceros in Ethiopia (Khalil, 1927).

The pinworm, *O. karamoja* was described by Baylis (1939) from specimens from a black rhinoceros in Uganda. Sub-



FIGURES 1–8. Scanning electron micrographs of anterior extremities of nematodes from black and white rhinoceroses from southern Africa. 1. *Kiluluma rhinocerotis* from the Mönnig collection at Onderstepoort Veterinary Institute (OVI), Republic of South Africa (SA). 2. *Kiluluma* spp. from a black rhinoceros female, (SA). 3. *Kiluluma goodeyi* from a black rhinoceros female, (SA). 4. *K. goodeyi* from the Mönnig collection (OVI). 5. *Kiluluma magna* from a black rhinoceros female, (SA). 6. *K. magna* from the Mönnig collection (OVI). 7. *Khalilia rhinocerotis* from a black rhinoceros from Namibia. 8. *Draschia megastoma* from a black rhinoceros female from the Republic of South Africa.

sequently it was reported from a white rhinoceros in southern Africa that had been sent to a zoological garden in Oita Prefecture, Japan (Usui and Horii, 1985) following antihelmintic treatment of the host. We found this parasite from white and black rhinoceroses in the Republic of South Africa and a black rhinoceros in Namibia. *Oxyuris equi* has been reported from the black rhinoceros in South Africa by Mönning (1926) 13 yr prior to the description of *O. karamoja* and it was probably the latter species.

According to Zumpt (1965) the immature stages of *G. pavesii* are found in both black and white rhinoceroses. The eggs are firmly attached to the skin of the head, but the conditions under which they hatch, how the larvae reach the stomach and where the second and third instars occur are unknown (Zumpt, 1965). The black rhinoceros from Umfolozi had only third instar larvae.

Using the checklists of Theiler (1962) and Baker and Keep (1970), our data, and records published in Norval (1985), we constructed checklists of the ixodid ticks reported on black and white rhinoceroses in the Republic of South Africa and Zimbabwe (Tables 2 and 3). Thirteen tick species are reported on black rhinoceroses in the Republic of South Africa and five are reported in Zimbabwe. White rhinoceroses in the Republic of South Africa may have eight ixodid tick species and those in Zimbabwe have seven. Two of these ticks, *A. rhinocerotis* and *D. rhinocerinus*, are virtually specific to rhinoceroses (Walker, 1991), while *A. hebraeum*, *A. sparsum*, *H. marginatum rufipes*, *H. truncatum*, *Rhipicephalus maculatus* and *Rhipicephalus simus* are common parasites of these and other large hosts in the Republic of South Africa and/or Zimbabwe. Of the 10 ornate tick species occurring in southern Africa, five (*A. hebraeum*, *A. rhinocerotis*, *A. sparsum*, *D. rhinocerinus*, *R. maculatus*) are regularly found on rhinoceroses within their distribution ranges.

Excluding elephants, the adults of *A. he-*

braeum prefer the large ungulates, while the larvae and nymphs feed on the same hosts as well as on many smaller animals (Horak et al., 1987). The large numbers of adults collected, particularly from the black rhinoceros in the Addo Elephant National Park and the two white rhinoceroses in the Kruger National Park, indicate that these animals may be among the preferred hosts of this tick.

Amblyomma rhinocerotis were not collected in our study, although Baker and Keep (1970) recorded it on animals in the Ndumu Game Reserve. Duncan (1989) counted large numbers of adults on black rhinoceroses in Zimbabwe. *Amblyomma sparsum* is found on rhinoceros in Zimbabwe (Duncan, 1989), but it does not occur in the Republic of South Africa and there are only two records from northern Namibia (Walker, 1991).

With the exception of the rhinoceros in the Addo Elephant National Park, all the animals we examined had *D. rhinocerinus*. According to Theiler (1962) this park lies outside the distribution range of the tick which at the time had been recorded only from KwaZulu-Natal. With the reintroduction of rhinoceroses into the Kruger National Park, this tick also was introduced or reintroduced, as is evident from the tick infections on the two white rhinoceroses examined there (Braack et al., 1995). The hosts of the immature stages are unknown.

Keirans (1993) suggests that *D. rhinocerinus* may soon become another member of the world's extinct fauna considering the current threatened status of its hosts. The success of the Republic of South Africa in the conservation of rhinoceroses will, at least in the short term, ensure the survival of this tick.

Despite the few *Hyalomma* sp. collected in this study, substantial numbers may occur on rhinoceroses (Duncan, 1989). Other large wild mammals may have considerable numbers of these ticks (Rechav et al., 1987; Horak et al., 1992a). These are two-host ticks and the immature stages prefer Cape hares (*Lepus capensis*) or

scrub hares (*Lepus saxatilis*) (Horak and Fourie, 1991).

With the exception of *R. maculatus* and *R. simus*, the *Rhipicephalus* spp. that are collected from rhinoceroses in southern Africa should probably be considered accidental parasites. In addition to rhinoceroses all the stages of *R. maculatus* seem to prefer large mammals such as buffaloes (*Syncerus caffer*) and bushpigs (*Potamochoerus porcus*) (Horak et al., 1983b; 1991), while the immature stages also will attach to many smaller animals (Horak et al., 1983b; 1988; 1991). In the Republic of South Africa this tick is confined to the coastal and closely adjacent regions in northern KwaZulu-Natal (Walker, 1991).

The adults of *R. simus* seem to prefer monogastric animals and are found on the larger carnivores, and on warthogs (*Phacochoerus aethiopicus*), zebras and rhinoceroses (Baker and Keep, 1970; Walker, 1991). The immature stages occur on rodents (Walker, 1991).

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LITERATURE CITED

- ACOCKS, J. P. H. 1988. Veld types of South Africa with accompanying veld type map. 3rd edition. Memoirs of the Botanical Survey of South Africa No. 57. 146 pp.
- ANDERSON, R. C., A. G. CHABAUD, AND S. WILL-MOTT. 1974. CIH keys to the nematode parasites of vertebrates. Numbers 1–10. CAB International Institute of Parasitology, Wallingford, Oxon, United Kingdom.
- BAKER, M. K., AND M. E. KEEP. 1970. Checklist of the ticks found on the larger game animals in the Natal game reserves. *Lammergeyer* 12: 41–47.
- BAYLIS, H. A. 1939. A new species of *Oxyuris* (Nematoda) from a rhinoceros. *Annals and Magazine of Natural History*. (Series 11) 3: 516–524.
- BRAACK, L. E. O., K. A. R. MAGGS, D. A. ZELLER, AND I. G. HORAK. 1995. Exotic arthropods in the Kruger National Park, South Africa: modes of entry and population status. *African Entomology* 3: 39–48.
- CAMPBELL, A. J. P., R. B. GASSER, AND N. B. CHILTON. 1995. Differences in a ribosomal DNA sequence of *Strongylus* species allows identification of single eggs. *International Journal for Parasitology* 25: 359–365.
- DUNCAN, I. M. 1989. The use of flumethrin pour-on for de-ticking black rhinoceros (*Diceros bicornis*) prior to translocation in Zimbabwe. *Journal of the South African Veterinary Association* 60: 195–197.
- EZZAT, M. A. E. 1945. Helminth parasites of some ungulates from the Giza Zoological Gardens, Egypt, with an appendix on some nematodes from the African Rhinoceros. *Bulletin, Ministry of Agriculture, Government Press, Cairo, Egypt. Technical and Scientific Service, Veterinary Section* 241: 1–104.
- FITZSIMMONS, W. M. 1962. *Parabronema roundi* n. sp. (Spiruridae: Nematoda) from *Rhinoceros bicornis* in Kenya. *Journal of Helminthology* 36: 39–44.
- GIBBONS, L. M., S. E. KNAPP, AND R. C. KRECEK. 1996. *Diceronema versterae* gen. n., sp. n. (Atractidae: Cosmocercoidea) from the black rhinoceros, *Diceros bicornis bicornis*, in South Africa. *Journal of the Helminthological Society of Washington* 63: 98–104.
- GISS, W. 1971. A preliminary vegetation map of southwest Africa. *Dinteria* 4: 5–14.
- HITCHINS, P. M., AND M. E. KEEP. 1970. Observations on skin lesions of the black rhinoceros (*Diceros bicornis*) in the Hluhluwe Game Reserve, Zululand. *Lammergeyer* 12: 56–65.
- HORAK, I. G. 1981. Host specificity and the distribution of the helminth parasites of sheep, cattle, impala and blesbok according to climate. *Journal of the South African Veterinary Association* 52: 201–206.
- , H. C. BIGGS, T. S. HANSEN, AND R. E. HANSEN. 1983a. The prevalence of helminth and arthropod parasites of warthog, *Phacochoerus aethiopicus*, in South West Africa/Namibia. *Onderstepoort Journal of Veterinary Research* 50: 145–148.
- , M. ANTHONISSEN, R. C. KRECEK, AND J. BO-

- OMKER. 1992a. Arthropod parasites of springbok, gemsbok, kudus, giraffes and Burchell's and Hartmann's zebras in the Etosha and Hardap nature reserves, Namibia. *Onderstepoort Journal of Veterinary Research* 59: 253–257.
- , J. BOOMKER, AND J. R. B. FLAMAND. 1991. Ixodid ticks and lice infesting red duikers and bushpigs in north-eastern Natal. *Onderstepoort Journal of Veterinary Research* 58: 281–284.
- , A. M. SPICKETT, AND V. DE VOS. 1992b. Parasites of domestic and wild animals in South Africa. XXX. Ectoparasites of kudus in the eastern Transvaal Lowveld and the eastern Cape Province. *Onderstepoort Journal of Veterinary Research* 59: 259–273.
- , K. M. DE F. MACIVOR, T. N. PETNEY, AND V. DE VOS. 1987. Some avian and mammalian hosts of *Amblyomma hebraeum* and *Amblyomma marmoreum* (Acari: Ixodidae). *Onderstepoort Journal of Veterinary Research* 54: 397–403.
- , AND L. J. FOURIE. 1991. Parasites of domestic and wild animals in South Africa. XXIX. Ixodid ticks on hares in the Cape Province and on hares and red rock rabbits in the Orange Free State. *Onderstepoort Journal of Veterinary Research* 58: 261–271.
- , M. E. KEEP, J. R. B. FLAMAND, AND J. BOOMKER. 1988. Arthropod parasites of common reedbuck, *Redunca arundinum*, in Natal. *Onderstepoort Journal of Veterinary Research* 55: 19–22.
- , F. T. POTGIETER, J. B. WALKER, V. DE VOS, AND J. BOOMKER. 1983b. The ixodid tick burdens of various large ruminant species in South African nature reserves. *Onderstepoort Journal of Veterinary Research* 50: 221–228.
- KEIRANS, J. E. 1993. *Dermacentor rhinoceros* (Denny, 1843) (Acari: Ixodida: Ixodidae): redescription of the male, female and nymph and first description of the larva. *Onderstepoort Journal of Veterinary Research* 60: 59–68.
- KHALIL, M. 1927. Une nouvelle espèce de *Parabronema* du rhinocéros (*Parabronema rhinocerotis* n. sp.). *Annales de Parasitologie Humaine et Comparée* 5: 37–40.
- KOCK, N., AND M. D. KOCK. 1990. Skin lesions in free-ranging black rhinoceroses (*Diceros bicornis*) in Zimbabwe. *Journal of Zoo and Wildlife Medicine* 21: 447–452.
- LICHTENFELS, J. R. 1975. Helminths of domestic equines. Illustrated keys to genera and species with emphasis on North American forms. *Proceedings of the Helminthological Society of Washington* 42: Special issue, 92 pp.
- MALAN, F. S., R. K. REINECKE, AND R. C. SCIALDO. 1981a. Recovery of helminths postmortem from equines. I. Parasites in arteries, subperitoneum, liver and lungs. *Onderstepoort Journal of Veterinary Research* 48: 141–143.
- , ———, AND ———. 1981b. Recovery of helminths postmortem from equines. II. Helminths and larvae of *Gasterophilus* in the gastrointestinal tract and oestrids from the sinuses. *Onderstepoort Journal of Veterinary Research* 48: 145–147.
- MELTZER, D. G. A. 1994. Diseases in free-ranging black and white rhinoceroses. In *Proceedings of a Symposium on "Rhinos as Game Ranch Animals"*, B. L. Penzhorn, and N. P. J. Kriek (eds.). South African Veterinary Association Wildlife Group, Onderstepoort, Republic of South Africa, pp. 176–179.
- MÖNNIG, H. O. 1926. Helminthological notes. In 11th and 12th Reports of the Director of Veterinary Education and Research. Department of Agriculture, Pretoria, Union of South Africa, pp. 221–228.
- . 1928. Check list of the worm parasites of domesticated animals in South Africa. In 13th and 14th Reports of the Director of Veterinary Education and Research. Department of Agriculture, Pretoria, Union of South Africa, pp. 801–837.
- NEVEU-LEMAIRE, M. 1924. Les strongylidés du rhinocéros africain (*Rhinoceros bicornis*). *Annales de Parasitologie Humaine et Comparée* 2: 121–154.
- NORVAL, R. A. I. 1985. Ticks (Ixodoidea) and tick-borne diseases in southern Africa. D.Sc. Thesis. Rhodes University, Grahamstown, Republic of South Africa, 577 pp.
- PENZHORN, B. L., R. C. KRECEK, I. G. HORAK, A. J. M. VERSTER, J. B. WALKER, J. D. F. BOOMKER, S. E. KNAPP, AND S. K. F. QUANDT. 1994. Parasites of African rhinos: A documentation. In *Proceedings of a Symposium on "Rhinos as Game Ranch Animals"*, B. L. Penzhorn, and N. P. J. Kriek (eds.). South African Veterinary Association Wildlife Group, Onderstepoort, Republic of South Africa, pp. 168–175.
- PETERS, W. 1856. Ueber eine neue durch ihre riesige Grösse ausgezeichnete *Taenia*. *Monatsschrift der Königlichen Preussischen Akademie für Wissenschaften Berlin, Germany*, 469 pp.
- RECHAV, Y., M. E. ZEEDERBERG, AND D. A. ZELLER. 1987. Dynamics of African tick (Acari: Ixodoidea) populations in a natural Crimean-Congo hemorrhagic fever focus. *Journal of Medical Entomology* 24: 565–583.
- ROUND, M. C. 1964. A new species of *Stephanofilaria* in skin lesions from the black rhinoceros (*Diceros bicornis* L.) in Kenya. *Journal of Helminthology* 38: 87–96.
- . 1968. Check list of the helminth parasites of African mammals. Technical Communication. No. 38. Commonwealth Agricultural Bureau, Bucks, England, 252 pp.
- SANDGROUND, J. H. 1933. Reports on the scientific results of an expedition to the southwestern highlands of Tanganyika Territory: VI. Parasitic nematodes from East Africa and Southern Rhodesia.

- Bulletin of the Museum of Comparative Zoology, Harvard 75: 263–293.
- SCIALDO-KRECEK, R. C. 1984. The nematode parasites of *Equus zebra hartmannae* and *Equus burchelli antiquorum* from different areas of Southern Africa. D.Sc. Thesis, University of Pretoria, Pretoria, Republic of South Africa, 261 pp.
- SKRJABIN, K. I. 1916. Parasitic trematodes and nematodes collected by the expedition of Prof. V. Dogiel and I. Sokolov in British East Africa. Review of the Zoological Expedition to British East Africa by Prof. Dogiel and Sokolov, 1914. 1: 157 pp.
- STUNKARD, H. W. 1926. The tapeworms of the rhinoceroses: a study based on material from the Belgian Congo. American Museum Novitates 210: 1–17.
- TAYLOR, E. L. 1925. The genus *Kiluluma*. Annals of Tropical Medicine and Parasitology 19: 53–55.
- THAPAR, G. S. 1924. On *Kiluluma*, Skrjabin, a genus of stronglylid nematodes parasitic in African rhinoceros. Journal of Helminthology 2: 209–238.
- . 1925. On some new members of the genus *Kiluluma* from the African rhinoceros. Journal of Helminthology 3: 63–80.
- THEILER, G. 1962. The Ixodoidea parasites of vertebrates in Africa south of the Sahara (Ethiopian region). Project S. 9958. Report to the Director of Veterinary Services, Onderstepoort, Republic of South Africa (Mimeographed), 260 pp.
- USUI, M., AND Y. HORII. 1985. *Oxyuris karamoja* (new record) recovered from white rhinoceroses. Bulletin of the Faculty of Agriculture, Miyazaki University 38: 211–216.
- VON LINSTOW, O. F. B. 1907. Nematoden aus dem Königlichen Zoologischen Museum in Berlin. Mitteilungen aus dem Zoologischen Museum in Berlin 3: 251–259.
- WALKER, C. H. 1994. Rhinos in Africa—The present situation. In Proceedings of a Symposium on “Rhinos as Game Ranch Animals”, B. L. Penzhorn, and N. P. J. Kriek (eds.). South African Veterinary Association Wildlife Group, Onderstepoort, Republic of South Africa, pp. 1–3.
- WALKER, J. B. 1991. A review of the ixodid ticks (Acari, Ixodidae) occurring in southern Africa. Onderstepoort Journal of Veterinary Research 58: 81–105.
- YORKE, W., AND P. A. MAPLESTONE. 1926. The Nematode Parasites of Vertebrates. J. & A. Churchill, London, England, 536 pp.
- YOUNG, E. 1966. Lesion in the vicinity of the eye of the white rhinoceros. International Zoo Yearbook 5: 194–195.
- ZUMPT, F. 1964. Parasites of the white and the black rhinoceroses. Lammergeyer 3: 59–70.
- . 1965. Myiasis in man and animals in the Old World. Butterworths, London, England, 267 pp.

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