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NEMATODE PARASITES FROM BURCHELL'S ZEBRAS IN SOUTH AFRICA

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ABSTRACT: Twenty-five Burchell's zebras (*Equus burchelli antiquorum*) which were culled at monthly intervals in the Kruger National Park were examined for helminths. Twenty-nine species of nematodes belonging to the families Atractidae, Habronematidae, Onchocercidae, Oxyuridae, Strongylidae, Strongyloididae and Trichostrongylidae were recovered. The cyathostomes (small strongyles) most abundant were *Cyathostomum tetracanthum, Cylicostephanus calicatus, Cylindropharynx* sp. (? *C. intermedia* Theiler, 1923) and *Cylicocyclus auriculatus. Cyathostomum alveatum, Cyathostomum montgomeryi, Cylicostephanus calicatus* and *Cylindropharynx* sp. (? *C. intermedia* Theiler, 1923) were the most prevalent cyathostomes (small strongyles) while *Craterostomum acuticaudatum* was the most prevalent of the large strongyles. Of all the species recovered those most abundant were *Crossocephalus viviparus* and *Probstmayria vivipara* with intensities of 100 to 3,857,772 and 18,400 to 104,120,467, respectively. Four new species, two *Triodontophorus* spp. (Strongylidae) and two *Habronema* spp. (Habronematidae) were identified. Furthermore, this study furnishes a first report of *Triodontophorus minor* in zebras. The fourth stage cyathostomes as well as the adults of 11 of the 14 species were present in significantly greater intensities in autumn and winter.

Key words: Nematode fauna, Burchell's zebra, *Equus burchelli antiquorum*, Kruger National Park, South Africa, seasonal effects.

INTRODUCTION

Zebras are relatively free ranging and as such represent equids untouched by man's control measures (i.e., anthelmintics). Parasitic studies of such equids may provide a baseline for both wildlife and equine parasitology. Surveys and seasonal trends may contribute to the understanding of the parasites' epizootiology.

Equids harbor 107 known species of helminths and of these 94 are nematodes (Lichtenfels, 1975; Levine, 1980). The largest group, the cyathostomes, includes 58 known species whose pathogenic potential is of interest (Lichtenfels, 1975; Scialdo-Krecek, 1984; Reinemeyer, 1986).

Although checklists exist for internal parasites of zebras, there are two defects in these reports. First, the lists of parasites do not appear complete. The origin of study material for those early investigations may have caused this since sampling at necropsy was random rather than quantitative. Secondly, the hosts were not defined to species level in the early records. For example, Theiler (1923) includes 48 equids, three of which are zebras. The only information she gives regarding her zebra host is that of their origin (Bossieshoek, Transvaal, South Africa). At the time of Theiler's work according to Smithers (1983), *Equus burchelli antiquorum* H. Smith, 1841 would have been the subspecies which inhabited the Bossieshoek area. Nevertheless, Round (1968) has placed Theiler's zebras under species of *Equus* Linnaeus, 1758. The greatest number of reports according to Round (1968) exist for *Equus burchelli* (Gray, 1824) and the remainder of reports known for other zebras are compiled into two groups, *Equus zebra* Linnaeus, 1758 and *Equus* spp. Except for Theiler (1923), Mönnig (1926, 1928) and Le Roux (1932) all reports listed are only incidental findings, which illustrates the paucity of information existing on nematodes of zebras.

Since studies on equine nematodes are

limited and only incomplete checklists exist for parasites of zebras, we surveyed the nematodes of 25 Burchell's zebras in the Kruger National Park (KNP), Republic of South Africa. The objectives of this study were to determine (1) the nematode fauna of these zebras, (2) the prevalence and abundance of those nematode species present and (3) whether seasonal trends of these nematodes were evident.

MATERIALS AND METHODS

Twenty-five Burchell's zebras were culled (one or two each month) from June 1980 to June 1982, in the southeastern portion of the KNP as part of the game management in that park. The KNP is situated between 25°12'S to 24°24'S and 31°36'E to 32°2'E (Fig. 1). The predominant vegetation types of this area are red bushwillow veld, thorny thicket and knobthorn/marula veld (Van Wyk, 1972). The most important trees of this area include the knobthorn (*Acacia nigrescens*), leadwood (*Combretum imberbe*), red bushwillow (*Combretum apiculatum*) and mopane (*Colophospermum mopane*).

The incisors of the zebras were examined and ages determined according to Smuts (1974). Twenty zebras were 4.5 to 30 mo of age and five were 5.5 to 16 yr old.

The monthly rainfall during the study period ranged from 0–237 mm, though the expected mean annual rainfall was 550–650 mm. The wet season includes summer and spring while the dry season is fall and winter. According to Gertenbach (1980), 1980 was the beginning of a dry cycle. The seasons were interpreted according to Sykes (1976) and adapted to the Southern Hemisphere. These are spring (22 September to 21 December), summer (22 December to 19 March), autumn (20 March to 20 June), and winter (21 June to 21 September).

Zebras were shot in the neck, bled and the carcasses transported to the Veterinary Laboratory, Skukuza, KNP for examination. Animals were necropsied within 30–60 min after death. They were skinned, eviscerated and their ages estimated. Postmortem examination followed the technique described by Malan et al. (1981a, b). The entire gastrointestinal tract and viscera of the abdomen and thorax, including the heart, aorta and its branches to the viscera, were removed from the carcass. All the branches of the aorta, with the exception of the arteria gastrica sinistra, were dissected from the intestinal tract, and subsequently each branch was isolated from

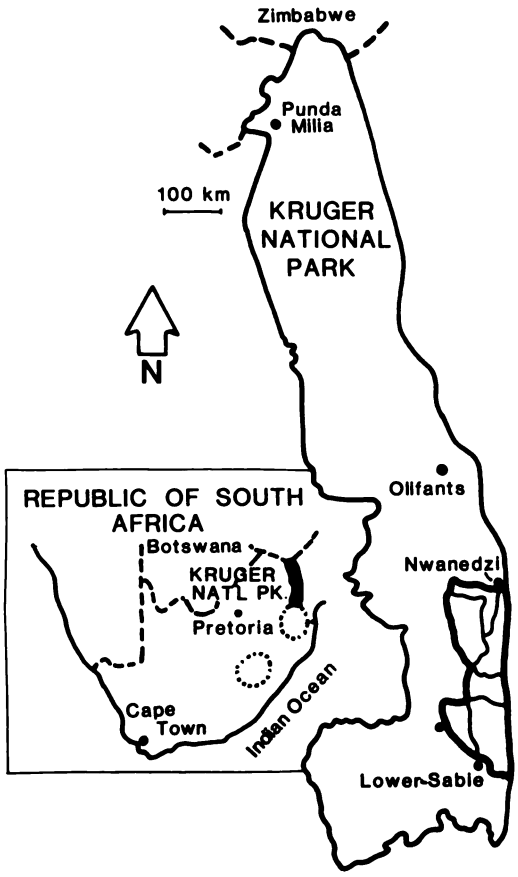

FIGURE 1. Kruger National Park (KNP) located in northeastern corner of South Africa (box). Enlarged KNP shows study area between Nwanedzi and Lower-Sabie outlined.

the mesentery, fat, pancreas, kidney, etc. The arteria ileocolica was examined carefully since it can be enlarged grossly due to chronic arteritis with thrombus formation caused by 4th stage larvae, 4th molt and 5th stage *Strongylus vulgaris*. The subperitoneal tissues, liver and lungs were also examined. The gastrointestinal tract was divided into stomach, small intestine, cecum, ventral colon, dorsal colon, descending colon and rectum, and each was examined separately. Aliquots of ingesta of ¼ by mass of the stomach and 1/10 by mass of the small intestine, cecum, ventral colon, dorsal colon and descending colon were collected for microscopic examination. Each part of the wall of the cecum, ventral, dorsal and descending colon was washed and specimens were collected for subsequent examination. The gut wall of the cecum and colon was examined macroscopically for larval

TABLE 1. Nematode fauna of Burchell's zebras from the Kruger National Park, South Africa.

Species of nematode	Prevalence %	Preferred sites in host[d]	Abundance[e] Mean	SE	Range	P^f for differences due to seasons
Cyathostominae						
Cyathostominae (L_4[a])	100	SI & LI	5,092.8	1,129	86–19,002	0.0148
Cyathostomum alveatum	100	DC	717.3	175	23–3,148	
Cyathostomum montgomeryi	100	Cecum	4,161.4	1,278	5–24,282	0.0333
Cyathostomum tetracanthum	96	DC	6,646.2	3,074	0–71,144	0.0316
Cylicocyclus adersi	48	DC	244.7	83	0–1,521	0.0478
Cylicocyclus auriculatus	88	VC	5,432.3	3,866	0–95,195	0.0843
Cylicocyclus gyalocephaloides	72	VC	227.5	65	0–920	
Cylicocyclus triramosus	92	Cecum	2,076.3	758	0–16,148	
Cylicodontophorus reineckei	24	VC	3.8	2	2–35	
Cylicodontophorus schuermanni	56	VC	1,212.0	424	0–9,565	0.0001
Cylicostephanus bidentatus	84	VC	883.0	1,279	0–5,115	0.0004
Cylicostephanus calicatus	100	DC	6,156.3	1,960	15–39,536	0.0693
Cylicostephanus minutus	56	VC	309.8	126	0–2,100	
Cylindropharynx sp. (? *C. intermedia*)	100	DC	6,266.44	1,664	10–32,405	0.0199
Poteriostomum ratzii	56	DC	108.5	56	0–1,269	0.0009
Strongylinae						
Craterostomum acuticaudatum	100	DC	2,416.3	460	65–8,390	
Triodontophorus spp. (L_4[a])	36	—	164.4	151	0–3,722	
Triodontophorus sp. (a)	32	VC	171.6	108	0–2,500	
Triodontophorus sp. (b)	4	VC	5.0[b]	0	5	
Triodontophorus minor	76	VC	1,252.7	904	0–22,175	
Triodontophorus serratus	84	VC	14.4	3	0–44	
Oxyuridae						
Oxyuris equi (L_4[a])	80	DC	2,385.1	900	0–20,706	
Oxyuris equi	84	DC	199.4	46	0–750	
Atractidae						
Crossocephalus viviparus	76	VC	535,763.0	209,758	0–3,857,772	
Probstmayria vivipara	96	VC	21,088,828.0	6,485,462	0–104,120,467	
Habronematidae						
Draschia megastoma	84	Stomach	151.4	56	0–1,160	
Habronema spp. (L_4[a])	28	—	2.8	1	0–26	
Habronema sp. (a)	96	Stomach	115.4	28.4	0–554	
Habronema sp. (b)	92	SI	32.7	13	0–267	
Habronema zebrae	8	Stomach	10.0	3	0–50	
Trichostrongylidae						
Trichostrongylus thomasi	44	Stomach	51.6	25	0–543	
Onchocercidae						
Setaria equina	40	PC	3.6	2	0–44	
Strongyloididae						
Strongyloides westeri	8	SI	1.6[c]	1	0–37	

stages. However, our techniques differed in one respect from Malan et al. (1981a, b); after the nematodes were killed with Lugol's Iodine and fixed in 10% formaldehyde they were recovered and stored in a mixture of 5% glycerine and 70% alcohol. *Crossocephalus viviparus*, present in high intensities were estimated according to Scialdo-Krecek et al. (1983). *Strongylus* spp. (Strongylinae) were identified, but are not reported in this study. Representative specimens of nematodes recovered in this study are deposited in the U.S. National Parasite Collection, Beltsville, Maryland 20705, USA (Accession Nos. 78990–79010).

Four new nematodes, two *Habronema* spp. and two *Triodontophorus* spp. were identified and are referred to as *Habronema* sp. (a), *Habronema* sp. (b), *Triodontophorus* sp. (a) and *Triodontophorus* sp. (b).

Cylindropharynx sp. (? *C. intermedia* Theiler, 1923) appears in this format in the present study (as discussed in Scialdo-Krecek, 1984). Although, the identification of this cyathostome demands further study it resembles most closely *Cylindropharynx intermedia* Theiler, 1923.

Overdispersion of the nematode species within the populations recovered from these zebras was measured according to the methods of Bliss and Fisher (1953). The terms prevalence, intensity, and abundance follow the definitions of Margolis et al. (1982). The ranked abundances (Conover and Iman, 1981) of the nematode species were compared across the seven seasonal intervals of the 2-yr period independently with a one-way analysis of variance (ANOVA) (Quade, 1966; Robbins and Van Ryzin, 1975). Differences in nematode numbers between years for the same season were not evident. Therefore, the abundances were pooled for winter, spring and summer and compared together with autumn for which data were available for a single year.

RESULTS AND DISCUSSION

Twenty-nine species of nematodes, including four new species were recovered from these Burchell's zebras. These included 14 cyathostomes (small strongyles), five large strongyles, one oxyurid, two atractids, four habronematids, one trichostrongylid, one onchocercid and one strongyloid. Data on prevalence and abundance for these species are listed in Table 1.

The variance was significantly greater than the mean (critical value for $\chi^2_{0.05\,(n=18)} = 28.9$) based on the numbers of individuals in the frequency distribution of all nematode species from the 20 sample data set of zebras. This indicated an overdispersed distribution (Bliss and Fisher, 1953) of these nematode species in this host.

The present study of 25 zebras spanned 19 mo from early winter 1980 to summer 1982. Therefore, it presents a more complete quantitative picture of the nematodes in Burchell's zebras than that of Scialdo et al. (1982) in which 10 zebras were killed at five separate intervals during 1 yr. Although Theiler (1923) studied three Burchell's zebras, her work was not quantitative and checklists such as Mönnig (1926, 1928) are of limited value because they do not clearly indicate which species of zebra was studied.

Two previously unknown species of *Triodontophorus* were recovered from these zebras as well as a first report of *Triodontophorus minor*. In addition, two unknown species of *Habronema* were identified.

The most abundant cyathostomes were *Cyathostomum tetracanthum, Cylicostephanus calicatus, Cylindropharynx* sp. (? *C. intermedia* Theiler, 1923) and *Cylicocyclus auriculatus. Cyathostomum alveatum, Cyathostomum montgomeryi,*

←

[a] L_4 = fourth stage larvae.
[b] Only one individual infected.
[c] Only two individuals infected.
[d] DC = Dorsal colon, VC = Ventral colon, SI = Small intestine, PC = Peritoneal cavity, LI = Large intestine.
[e] Abundance (according to Margolis et al., 1982) is the total number of individuals of a particular parasite species in a sample of hosts ÷ total number of individuals of the host species (infected and uninfected) in the sample.
[f] When *P* values not shown, the probability of no effect on abundances is >0.10. Levels of significance were determined by one way analyses of variance (ANOVA) on ranked abundances.

TABLE 2. Seasonal mean intensities of cyathostomes in Burchell's zebras from the Kruger National Park, Republic of South Africa.

Species of nematode	Winter (n = 8)	Spring (n = 8)	Summer (n = 3)	Autumn (n = 6)
Cyathostominae L_4[d]	6,410[a]	1,192[b]	1,167[b]	8,758[a]
Cyathostomum alveatum	397[a]	937[a]	582[a]	739[a]
Cyathostomum montgomeryi	10,969[a]	1,227[b]	1,363[b]	1,985[b]
Cyathostomum tetracanthum	18,365[a]	1,912[b]	685[b]	955[b]
Cylicocyclus adersi	11[b]	139[b]	441[ab]	767[a]
Cylicocyclus auriculatus	12,210[a]	2,344[ab]	201[b]	616[b]
Cylicocyclus gyalocephaloides	403[a]	244[a]	426[a]	5[a]
Cylicocyclus triramosus	5,006[a]	1,044[a]	543[a]	996[a]
Cylicodontophorus reineckei	7[a]	5[a]	4[a]	0[a]
Cylicodontophorus schuermanni	3,397[a]	92[c]	0[c]	1,023[b]
Cylicostephanus bidentatus	2,357[a]	585[b]	462[b]	41[c]
Cylicostephanus calicatus	14,830[a]	2,559[b]	1,792[b]	2,658[b]
Cylicostephanus minutus	815[a]	39[a]	5[a]	243[a]
***Cylindropharynx* sp. (? *C. intermedia*)**	15,144[a]	4,401[ab]	4,684[ab]	1,135[b]
Poteriostomum ratzii	26[b]	1[c]	63[ab]	380[a]

[a,b,c] Means followed by identical letters are not significantly different ($P > 0.10$).
[d] L_4 = fourth stage larvae.

Cylicostephanus calicatus and *Cylindropharynx* sp. (? *C. intermedia* Theiler, 1923) were the most prevalent cyathostomes and *Craterostomum acuticaudatum* the most prevalent of the large strongyles (Strongylinae). Of all the species of nematodes those with greatest abundances were the atractids, *Crossocephalus viviparus* and *Probstmayria vivipara*.

The number of species of strongyles and their species' abundances in a population of zebras may be directly related to the climatic conditions upon which the preparasitic stages are dependent in terms of their development. The amount of rainfall is critical to the development of these stages in many of the strongyles (Ogbourne, 1972, 1973) and, together with temperature, can greatly influence how rapidly the infective third stage is reached (Hummelinck, 1946; Ogbourne, 1972). In studies of the nematodes of Burchell's zebra (Scialdo et al., 1982; Scialdo-Krecek, 1983; Scialdo-Krecek et al., 1983; Krecek, unpubl. data), the KNP represents a high rainfall area (387–697 mm annual rainfall) and 14 species of cyathostomes were identified. By contrast, there were only seven species of cyathostomes in mountain zebras (*Equus zebra hartmannae*) (164–324 mm annual rainfall) (Scialdo-Krecek et al., 1983) from South West Africa/Namibia. Therefore, the higher rainfall area seems to support greater abundances of a larger number of cyathostome species.

Perhaps these climatic and environmental factors account for the significant differences detected in the adult stages recovered for 9 of the 14 cyathostomes when compared across the four seasons. The intensities of fourth stage cyathostomes (L_4) recovered in autumn and winter were significantly greater than in spring and summer (Table 2). This supports Ogbourne (1976) who recovered large numbers L_4 cyathostomes from horses in England during winter months. Additionally, the overwintering of fourth stage trichostrongylids in ruminants is well documented (Michel, 1974).

Intensities of the adult stages of nine of the 14 cyathostomes were significantly greater in the winter season. For two additional cyathostome species the greatest intensities were recovered in autumn and these were also significantly different. No

pattern, however, emerged for summer and spring. The presence of the large numbers of adult stages in the host's gastrointestinal tract in winter suggests that the factor(s) responsible for the emergence and development of L_4 to adults may have been present. That two additional species were present in larger numbers in autumn also supports this. Michel (1974) discusses the two causative factors (seasonal and host) for arrested development of nematodes. Warming air temperature, for instance, could be a signal for early emergence of L_4's. Possible host factors may be age, sex or experience with previous infection. Because of the greater intensities of L_4's in autumn and winter and presence of adult cyathostomes in winter, our study suggests that conditions were present that provided for overwintering of L_4's, their emergence and development to adults. In a temperate climate with relatively mild autumns and winters, as in the present study, perhaps these zebra cyathostomes exhibit an adaptation to survival in what could be a rather harsh environment outside the host.

The Burchell's zebras examined were predominantly younger animals with 20 <2½ yr old. A greater abundance of both L_4 and adult stages of *Oxyuris equi* were accounted for in these young zebras. Drudge and Lyons (1977) found that infection with *O. equi* in domestic horses was mainly in weaned foals and yearlings and that adult oxyurids were rare in older animals. These authors were of the opinion that the L4 could be found in horses of all ages and infections numbering several thousand were often present. The present study supports these views where 20,706 L_4 *O. equi* were recovered from an 8-mo-old zebra foal while most of the adult oxyurids were recovered from the young zebras.

Infections of *Strongyloides westeri* in young horse foals are reported to usually disappear completely between 15–25 wk of age (Russell, 1948; Lyons et al., 1973); however, results vary. Reinecke and Brooker (1972) recovered infective larvae of *S. westeri* in feces of aged horses as well as from donkeys and adult *S. westeri* at necropsy in the same donkeys. In the present study, two young zebras (5 and 18 mo of age) accounted for the 8% prevalence in the total population. The older zebra was certainly older than any horse in which the presence of *S. westeri* was reported by Russell (1948) and Lyons et al. (1973), but not for horses and donkeys recorded by Reinecke and Brooker (1972).

Poteriostomum ratzii occurred most frequently in the dorsal colon in Burchell's zebras as previously reported for horses (Ogbourne, 1976; Mfitilodze and Hutchinson, 1985). Distribution of *Cylicostephanus minutus* was found in the ventral colon, as in horses (Hasslinger, 1963; Ogbourne, 1976; Mfitilodze and Hutchinson, 1985).

We recovered *Cylicostephanus calicatus* primarily from the dorsal colon. In contrast, Theiler (1923) did not recover this species from zebras. Mfitilodze and Hutchinson (1985) reported this cyathostome from the cecum and ventral colon while Ogbourne (1976) and Hasslinger (1963) found it in the ventral colon of horses. Scialdo-Krecek (1983) reported this species from the cecum and ventral colon in Burchell's zebras.

Horak (1983) suggested that parasites may provide a system either for monitoring overpopulation, or disease in a population, or provide an indication of the weaker members of the host population. Results from the present study may be applied ultimately to such a program, but this will be possible only when we have a better understanding of the population dynamics of both the equine host and its nematode parasites.

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